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Illuminating Engineer

XXVII. August, 1934 Price

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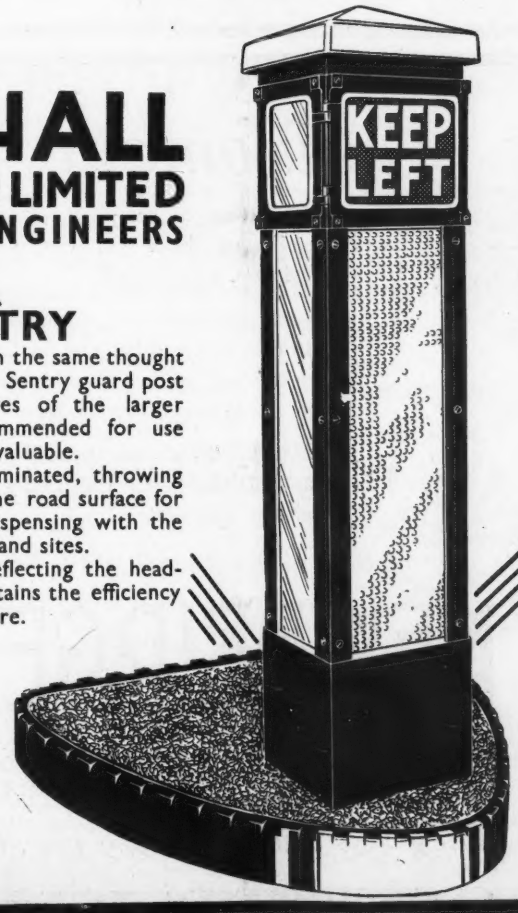

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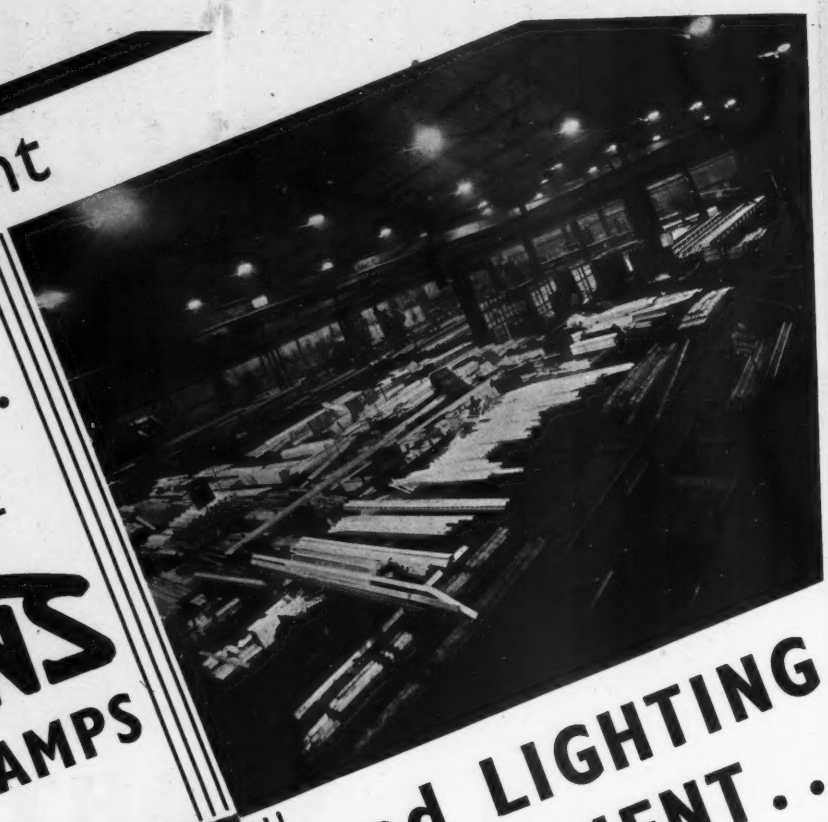

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• CATALOGUES SENT ON APPLICATION

Official Journal of THE ILLUMINATING ENGINEERING SOCIETY
FOUNDED IN LONDON 1909
INCORPORATED 1930

The ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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Principal Contents:

The Lighting of the King's Highway

THE Story of Public Lighting has often been told, how originally every householder must hang a lantern outside his door, and how this duty was gradually transferred to the community.

To-day there are many public bodies, some large, some small, all tending the lighting of the roads in their areas. Each carries out its own ideas, according to the funds at its disposal.

Important national thoroughfares, connecting city and city, now run through these scattered areas. They were made, not to serve local needs, but for the conveyance of traffic from afar. Therefore it is just and right that their maintenance should not be a burden on rural communities. The State contributes to their upkeep.

We say that the Lighting of the King's Highway should also be a national duty. By all means make use of local talent; let the public lighting engineer, where there is one, do his task, but let the State help him and his Committee to maintain adequate lighting, so that all may journey in comfort and safety.

Street Lighting Committee

We learn that the Ministry of Transport have set up a Departmental Committee "to examine and report what steps could be taken for securing more efficient and uniform street lighting with particular reference to the convenience and safety of traffic."

The members of the committee are:—Mr. F. C. Cook, D.S.O., M.C. (Deputy Chief Engineer, Ministry of Transport) (*Chairman*); Mr. J. F. Colquhoun (Public Lighting Engineer, Sheffield); Mr. C. A. Masterman (Chief Technical Officer, Gas Light and Coke Company); Major W. H. Morgan, D.S.O. (County Engineer, Middlesex); Mr. C. C. Paterson, O.B.E. (Director of Research Department, General Electric Company); Mr. E. S. Perrin (Ministry of Transport); Major L. Roseveare (Borough Engineer, Eastbourne); Mr. J. R. Taylor (Ministry of Transport); and Dr. J. W. T. Walsh (National Physical Laboratory). The Secretary is Dr. H. F. Gillbe.

Readers will be much interested to observe this definite evidence of the interest in street lighting now being taken by the Ministry of Transport. We hope that the Committee's inquiry will result in a more uniform standard of public lighting—especially in London, where the fact that it is handled by so many different authorities is apt to give rise to anomalies.

Public Lighting and Street Fatalities

Confirmation of some of the inferences on the above subject made in our last issue, July, 1934, p. 230, is afforded by a Report of the Detroit Police Department which was recently analysed in the Transactions of the American Illuminating Engineering Society. In 1931, when full street lighting was in force, fatal accidents occurring by day formed 49 per cent., and fatal accidents occurring by night 51 per cent. of the total—i.e., the numbers were approximately equal. In 1932, however, when, as a measure of economy, only 65 per cent. of the previous street lighting was provided, 33 per cent. of accidents occurred by day and 67 per cent. by night—a truly remarkable change. In 1933 when the street lighting was partially restored to 85 per cent. of its original value, a tendency to return to the original ratio of accidents was noted, the numbers of accidents occurring by day and by night being respectively 40 per cent. and 60 per cent. These figures certainly seem to afford striking evidence of the relation between public lighting to traffic accidents occurring by night. It would be interesting, however, to have confirmatory evidence from towns in this country where experiments with diminished street lighting have been made.

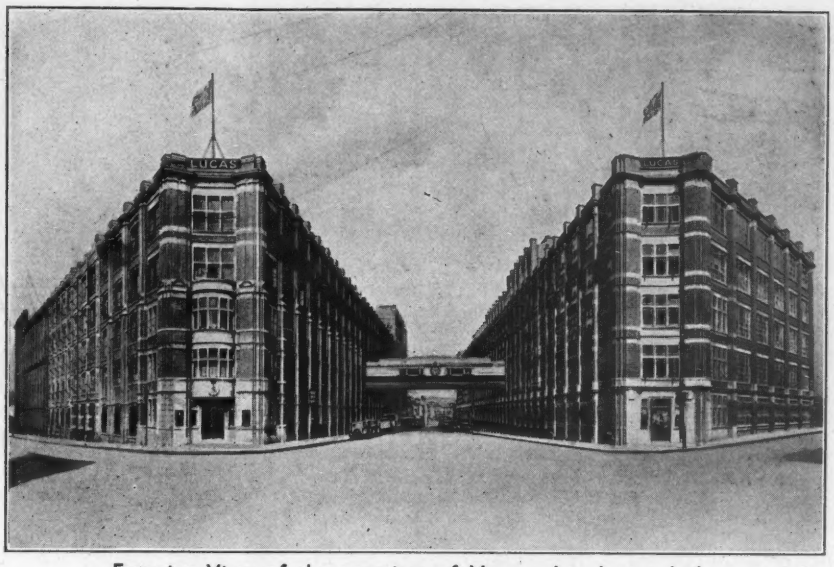
Public Lighting—Annual Reports

Oldham and Sheffield

The annual report of the Superintendent of Public Lighting in Oldham (Mr. I. H. Massey) contains records of consumption and price of gas and electricity and expenditure on public lighting from 1924 (when the separate street lighting department was formed) up to the present year. During the decade the Department has more than justified its existence. The candle-power provided has increased from 988,990 to 1,159,690—an increase of 17.2 per cent.; whereas the expenditure has decreased from £29,769 to £21,329—a diminution of 28.3 per cent. Evidently in Oldham a policy of economy has been judged necessary, but one notes that every effort is made to get more efficient lighting by the introduction of improved burners and lanterns, refractors, and stainless steel reflectors. In a number of cases two-feet extensions have been used to increase the height of lanterns. Experiments with electric discharge lamps are being made.

In Sheffield, also, the Lighting Department has just completed ten years as an independent department of the Corporation. Mr. Colquhoun, the public lighting engineer, again makes effective use of charts and diagrams illustrating changes during this period. It is striking to note that the cost of lighting service per head (2/2) is now almost identical with that for 1924-25, whereas the candlepower provided per head of population has risen from 2 to nearly 5. One notes that the number of electric lamps in Sheffield, now over 5,000, was only 287 in 1924. Other interesting points emerge from the report—for instance that the average effective life of gas mantles is now 1,795 burning hours, an increase of 195 hours over the figure for the previous year—certainly a remarkably good result to be obtained with mantles used for public lighting. Experiments are now being made with electric discharge lamps and also with the automatic lighting of gas lamps by the catalytic method.

Good Industrial Lighting No. 6



Exterior View of the premises of Messrs. Jos. Lucas, Ltd., Gt. King Street Works, Birmingham.

Intensive General Lighting in a Modern Factory

THE first five articles in this series were devoted to general principles of industrial lighting. It is now proposed to deal in turn with a number of special installations, showing how these principles have been applied in practice, and how special problems in industrial lighting have been solved.

This—(our sixth)—specially contributed article is concerned with the highly modern works and offices of Messrs. Jos. Lucas, Ltd., of Birmingham, illustrated above.

As an introduction we may recall the general belief, mentioned previously, that good lighting *does* have a material influence on speed of production and quality of work, in addition to its admitted value to the health of workers. This view is now so widely held that in modern factories diffused general lighting furnishing 10 to 12 foot-candles is becoming quite usual; one might, indeed, almost regard the use of 200 watt lighting units spaced 12 ft. apart as standard practice.

This, needless to say, represents a great advance as compared with the conditions usual in factories only a few years ago. Yet there is evidence that still higher illuminations can often be furnished with advantage. In a now familiar research* it has been shown that in the case of typesetting by hand illuminations of 20 to 25 foot-candles are necessary to ensure full efficiency of operations comparable with that in daylight.

Twenty Foot-Candles Provided.

Experience has led some modern firms to adopt this view, one of the first to do so being Messrs. Jos. Lucas, Ltd., who decided about a year ago to re-equip all the shops in their immense works in Birmingham, so as to bring the standard of lighting up to 20 foot-candles. Some years ago a standard of 10 foot-candles had been agreed upon, 200 watt gas-filled lamps in Holophane Extensive type prismatic industrial units being accordingly installed on centres 10 ft. 6 in. by 13 ft. 6 in.

The revolutionary change from 10 to 20 foot-candles involved a new scheme of wiring. Two alternative methods presented themselves (a) to substitute 300 watt lighting units and slightly diminish the spacing and (b) to retain 200 watt units, but to mount them on centres approximately 9 ft. apart. The second scheme was finally adopted, and already numerous and extensive sections of the works have been thus equipped.

This method presents several advantages.

Firstly, the unusually close spacing results in a system of lighting approaching more closely a "luminous plane" (e.g., an illuminated ceiling) and thus eliminates to a great extent the objection often raised against direct lighting—that it is apt to produce troublesome shadows. With lighting units placed so near together there is considerable overlap and inconvenient shadows practically disappear.

Secondly, the arrangement furnishes symmetrical and uniform lighting conditions, irrespective of the positions of desks or machines, the positions of which may, therefore, be altered without it being necessary to modify the lighting equipment in any way.

Thirdly, this method of using Holophane Extensive type industrial units results in a fairly high percentage of the direct light being returned, as reflected light, from floors and working surfaces, thus leading to relatively bright surroundings—a very important consideration in the modern factory.

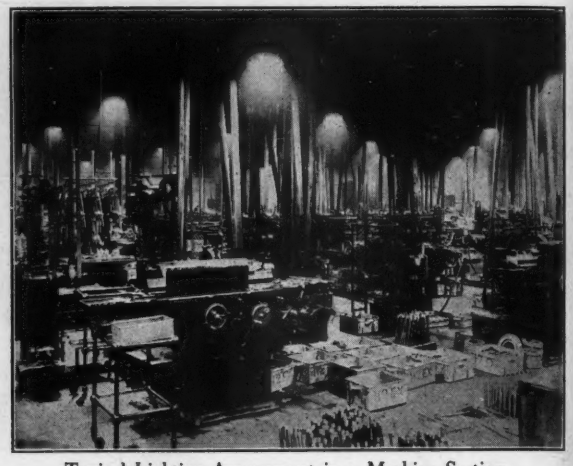
The retention of 200 watt units was also expedient from the standpoint of diminishing any possible glare, as the ceiling height on some floors is restricted to about 11 ft., and it was, therefore, desirable to avoid increasing the brightness of lighting units.

Imitation of Daylight.

The Lucas Works also afford an instructive example of the application of another modern practice—the

* The Relation between Illumination and Efficiency in Fine Work (Typesetting by Hand): Report issued under the auspices of the Medical Research Council and the Department of Scientific and Industrial Research (1926).

Typical Lighting Arrangement in an Assembly Section.
(Messrs. Jos. Lucas, Ltd., Birmingham).



Typical Lighting Arrangement in a Machine Section.
(Messrs. Jos. Lucas, Ltd., Birmingham).

use of semi-corrected "artificial daylight," which has now been adopted throughout the entire office block.

The construction of these office buildings is such that during a great part of the day artificial light is certain to be needed in certain areas, whilst daylight still suffices in others; in other parts of the rooms, again, a mixture of natural and artificial light will be used.

Now it is a familiar fact that working in a mixed light, composed partly of weak daylight and partly of yellowish artificial light, is always trying. During the period when daylight begins to fail and lights are switched on the artificial lighting almost invariably seems insufficient; although, once the daylight has completely disappeared, it may appear satisfactory. This is, no doubt, in part occasioned by the fact that the eyes take an appreciable time to adapt themselves to the lower level of artificial lighting; but it is certainly influenced to a very great extent by the difference in colour, for the apparent "inadequacy" is not nearly so noticeable when the artificial light has been corrected so as to resemble daylight approximately in colour.

In order to meet this condition it was decided to install semi-corrected lighting throughout the four floors of the general office block. The lighting units consisted of Holophane 14 in. semi-corrected units equipped with 300 watt gas-filled lamps, mounted on 11 ft. centres. Approximately 500 units of this type have been installed. The installation is doubtless the largest of its kind in the country. It is interesting to learn that the arrangement gives complete satisfaction to the workers, and that this effort to bridge the gap between natural and artificial lighting conditions has proved to be well worth while.

A Typical Section of General Office Lighting using Holophane Semi-Corrected Daylight Units.

Figure 1. A most effective night picture of Anniesland Cross, Glasgow, for which the photographers (Messrs. T. & R. Annan & Sons) deserve great credit. 300-watt and 500-watt gasfilled lamps are mounted on the high masts, and are helped out by the "Pillar of Fire" illuminated bollards on the various refuges. The reflective value of a good street surface is strikingly shown on the first island, in the foreground, which is laid in concrete. In the background, between the posts, is seen a splash of light, a Neon sign for the Castlebank Laundry.

Public Lighting Developments in Glasgow

We are indebted to Mr. S. B. Langlands, Inspector of Lighting to the Corporation of Glasgow, for the above striking photograph of Anniesland Cross, and also for the two pictures below, which show the comparative effect on a wet and dry street-surface of the Osira lamps recently installed on ten consecutive posts in South Portland Street. The street is an important one, being parallel with the main road southward, and frequently used as a relief to traffic. It has a carriage way 45 ft. wide and a footpath 10 ft. wide. The lamps are housed in the standard Glasgow pattern lanterns, which are attached to brackets on extension pieces on tram poles, making the mounting height 27½ ft. The average spacing between lamps, which are in "staggered" formation, is 35 yards, measured along the centre of the line of the carriage way.

We understand that comparisons with other systems have been based largely on observations of brightness of the road surface from different points of view. (In this respect the comparisons on wet and dry surfaces have doubtless proved instructive.) The natural distribution of light from the Osira lamp is believed to be better suited than that of filament lamps to lanterns of the Glasgow Corporation type (which have no directive equipment other than that comprised in the pine-shaped outer globes and the large over reflector), and, in view of the good spacing height ratio (4 or 4.5 to 1), should yield very even distribution of illumination.

Photo: W. Ralston, Glasgow

Figure 2. Night Photograph of South Portland Street, Glasgow, illuminated by Osira lamps: effect on a dry night.

Photo: Annan

Figure 2. The effect of the same installation on a wet night.

Illuminating Engineering in Australia

Progress and Practice in New South Wales

[We are indebted to Mr. A. P. Turnbull, of the New South Government Railways, Sydney, and to Mr. W. Wadey, of Adelaide, for the following account of lighting developments in these two cities. Readers will learn with pleasure of the steady progress being made by the Illuminating Engineering Societies in Australia, and will be interested in the installations described, notably the underwater lighting of the large bathing pools illustrated on the opposite page.]

The growth of illuminating engineering in Australia, and the activities of the Illuminating Engineering Societies there, are naturally proceeding on lines determined by local conditions.

So far as numbers are concerned the community in Australia is even now, not large, and is spread, somewhat patchily, over an immense area. For some time to come, therefore, progress in illuminating engineering must be largely a reflection of developments in other countries. Much data appearing in the transactions of the local society must necessarily be garnered from material published elsewhere. If, as is usual, references are quoted this resurrection of previously published data is quite a proper course and has the advantage that the rebroadcasting of data enables it to reach places that would otherwise remain unenlightened—thus spreading the good work of the original authors.

Illuminating Engineering Societies.

The Illuminating Engineering Society has so far divisions in only two of the six States which comprise the Australian Commonwealth—namely New South Wales and Victoria. The bulk of the total membership (200 members of all grades) resides in these two States, but there is a small sprinkling of members scattered throughout the remaining States and it is anticipated that in the near future further State divisions will be formed in Queensland and South Australia.

The New South Wales Division, the parent organisation, is now incorporated as a professional society, with limited liability of members, under the Companies Act, New South Wales. It is possible that similar action will be taken by the Victorian division shortly. (Unfortunately each State has its own law in regard to the company registration, etc., and, therefore, each division has to be registered as a separate entity in its own State.)

Electrical, Radio and Lighting Exhibition.

In the main the members of the local Illuminating Engineering Society are associated with the electrical and radio industries. This community of interest has helped the growth of the Society very greatly in its initial stages. These kindred societies (electrical, radio and illuminating) have instituted a remarkably successful annual exhibition in connection with their respective activities. The exhibitions are held in the Town Hall, Sydney, and usually remain open for a week. The lighting and decorating work is entrusted to the Illuminating Engineering Society which has also a special display of its own. The admission charge is 6d. a head and the attendance this year reached 69,584—an increase of about 10,000 as compared with the previous year. (On one day the doors had to be closed three times to prevent overcrowding!)

The lighting field in Australia is almost exclusively electrical. Even in remote country places automatic petrol-electric generating sets for lighting station homesteads and outbuildings are frequently met.

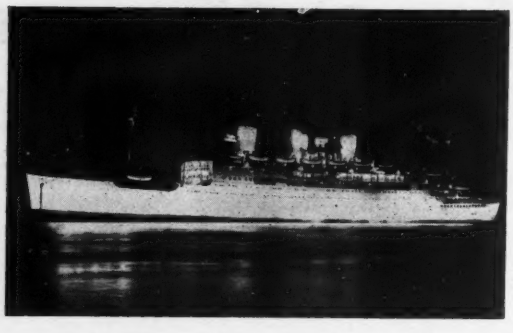


Figure 1. R.M.S. Strathnavon floodlighted at Wharf in Sydney Harbour by Philips Lamps, Ltd. (Aus.).

New Lighting Businesses.

In spite of the industrial depression there has been of late considerable progress in illuminating engineering, a feature being the increased application of luminous tubing in the form of illuminated signs. The improved position is further exemplified by the advent of new businesses founded on illumination work alone. Of these may be specially mentioned "Better Lighting Ltd.," which specialises in the manufacture, supply, and installation of equipment; the founder and chief driving force is Mr. E. W. Williams who is a past president of the Illuminating Engineering Society (Australia), New South Wales Division, and is also a member of long standing of the Illuminating Engineering Society in England. Another business specialising in illumination but on a more modest scale is "Lomax Lighting" which is conducted at Angel Place, Sydney by Mr. Donald G. Stevens. The General Electric Co., Ltd. (England) and the British Thomson Houston Co., Ltd., have also displays of lighting in their showrooms (which, however, are not confined to lighting only), and their local branches keep the community in touch with the latest progress.

The Lighting of Swimming Pools.

A number of modern swimming pools have been built in the suburbs and in country towns, and are provided with lighting in accordance with the latest practice, which includes under water lighting. One type of pool is formed by fencing in an area of open

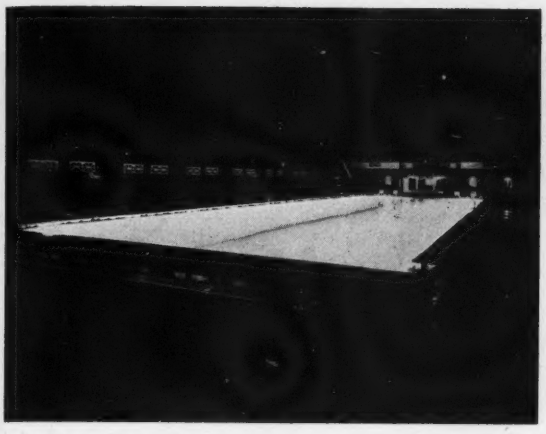


Figure 2. A fine example of "underwater lighting." The Enfield Olympic Swimming Pool, for which 750 w. submerged units were used by the Egarsol Lighting Co., Ltd.

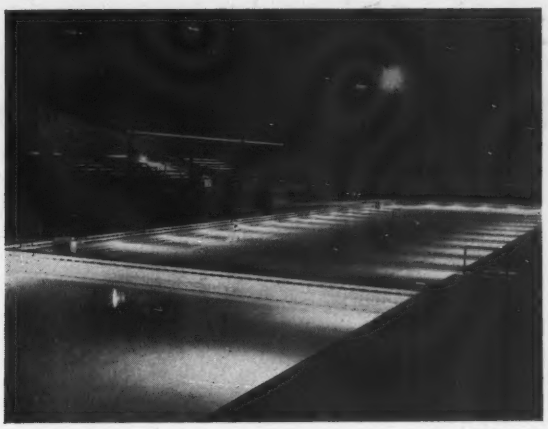


Figure 3. The Bankstown Swimming Pool, also illuminated under water by 33 (500 w.) dry-niched (American) floodlighting units.

salt water against shark attack. Of this type the Manly pool (fig. 4) is a good example. There are also fresh water pools with white tiled basins and equipment for maintaining the water in pure condition. The Enfield and Bankstown pools (Figs. 2 and 3) are instances.

Although floodlighting has been used in New South Wales for the past ten years in connection with railway yard lighting and later on sports grounds, it has only recently been extended to the permanent lighting of frontages of buildings. In this connection mention may be made of a local product, a new form of reflector so designed as to reduce substantially tendency to glare and dazzle. These reflectors are marketed under the name of "Egarsol." Another novel floodlighting projector has been designed by a local engineer, but as yet particulars are not available for publication.

Figure 4. A view of the Manly (Sydney) Swimming Pool by night. The piles supporting the Esplanade on the right of the picture are also used to support the shark-proof netting. Submerged floodlighting projectors are responsible for the illuminated areas of the water. The bright spots in the background are the lights of residences on the distant hills.

An Electrical Association for Women was launched in Sydney on March 22, and started with an enrolment of no less than 1,000 members. This is affiliated with the British Association of the same name.

Test of Electric Discharge Lamps.

The Adelaide City Council has been turning its attention to electric discharge lamps, and it is stated that tests with sodium and "Osira" lamps are projected. Other illustrations before us relate to improvements in industrial and shop lighting in the Adelaide area, but these we must leave over until a subsequent issue.

It will be recalled also that, during the period October, 1934, to March, 1935, the City of Melbourne will be celebrating its first centenary. Illumination is to play an important part in the programme, illustrating one hundred years of progress. We hope that from this quarter also interesting information will be forthcoming.

Figure 5. The up-to-date showrooms of "Better Lighting, Ltd.," for whom Mr. E. W. Williams is Managing Director and Chief Illuminating Engineer, Clarence Street, Sydney.

Figure 6. The Embassy Ball Room, Adelaide, in which modern "architectural lighting" fittings have been installed.

York's Civic Week

Floodlighting with Gas

[We are indebted to the Gas Journal for the illustrations accompanying this note.]

Our attention has been drawn by Mr. H. E. Bloor, Engineer and Manager of the York Gas Company, to the floodlighting with gas of various buildings of historic interest during the recent celebration of York's Civic Week.

The accompanying illustrations give an idea of the effects obtained, some of which—especially the floodlighting of the Ouse River Front, shown below, which

Figure 2. Bootham Bar and part of Old Abbey Walls.

is quite reminiscent of evening effects on the canals in Venice—were very pleasing.

An interesting feature of this scheme of floodlighting was that the projectors were housed in boats anchored in the river, gas being supplied from cylinders filled at a pressure of 80 atmospheres. The

Figure 1. The Bar Walls, Old Mortuary, and Lendal Tower.

projectors were of the "strip lantern" type, such as readily lend themselves to floodlighting schemes in which a relatively diffused light is needed.

Dark Nights in Bisley

A few months ago we referred to the sad case of Orford, a village in Suffolk, possessing no street lighting. Another case is furnished by Bisley, a village with a famous name which, although only just over twenty-five miles from London, does not possess a single street lamp. According to statements in the Press it appears that a 1d. rate in Bisley would produce only £23, and that to erect and maintain eleven street lamps in the first year would mean an increase of 5d. in the rates. It is stated that the residents have so far decided against incurring this expense, so that unless this decision is reversed the streets of Bisley will continue to go unlighted. Such cases surely furnish a striking argument in favour of making the lighting of highways through such rural areas a national duty! They also illustrate the difficulty of the plan proposed in the recent Transport Act of making the provision of street lamps an indication of built-up areas (in which a speed limit is to be imposed).

Figure 3.
A pleasing view of the River Ouse, floodlighted with gas, showing the Guildhall and Lendal Tower.

A Review of Photo-Electric Photometry and Its Limitations

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SUMMARY.

Three main sections deal with the basis of visual photometry, the adaptation of the photo-cell to the visual system, and sources of error in photo-electric photometry, with vacuum photo-cells of the Elster-Geitel type.

The difficulties underlying the application of what is really a type of radiometer to the measurement of light, which is basically a physiological sensation, are critically surveyed. The fundamental differences between the photo-cell and the eye as regards response to colour and illumination are emphasised. A discussion of the various possible errors in photo-electric photometry follows. These errors fall into two main divisions—physical, and mechanical or geometric.

The authors conclude that while photo-electric methods facilitate enormously routine photometry to a precision of 1 or 2 per cent., serious difficulties have generally to be dealt with in the attainment of a precision equal to that obtainable visually under favourable conditions. This is partly due to the fact that errors in photo-electric observations are frequently systematic and related to the particular experimental conditions such as colour difference of the light sources. The photo-cell is, however, admirably suited to the comparison of illuminations of practically identical spectral distribution (where the values compared are in a ratio not very different from unity), and to the measurement of small differences or changes under constant colour conditions.

INTRODUCTION.

The rapid improvement in the design and methods of manufacture of commercially available photo-cells which has recently taken place has resulted in the raising of the status of the cell from that of a mere detector of radiation to that of a measuring instrument of value for precise work. While the improved photo-cell is really an instrument for the measurement of radiant energy, of any wavelength within the limits of sensitivity of the cell, there has, in fact, been a great tendency to regard the photo-cell mainly as a new instrument for measuring *light*—i.e., a photometer rather than a radiometer. The usefulness of the photo-cell for measurement of light is not to be undervalued, but this tendency has resulted in the photo-cell being regarded frequently as simply a substitute for the eye, while, in fact, the differences between the two are, in some respects at least, fundamental.

The importance of these fundamental differences and the errors which they involve becomes apparent in high precision photometry to an extent not always realised by those engaged in routine commercial photometry, where speed of operation and freedom from errors of judgment are primary considerations.

The point of view taken in this paper is therefore that of the worker in a standardising laboratory, where speed of operation is of minor importance, but where every error must be traced and assessed accurately. For the sake of completeness and of emphasis upon the ultimate visual basis of all photometry, the whole problem of the application of photo-cell to light measurement is examined ab initio.

The first question which arises is whether it is better to build up a system of photometry utilising the properties of the photo-cell as a fundamental basis (i.e., in effect, using the cell as a radiometer), or to adapt the cell directly to the present visual system and to use it together with a compensating filter, as nearly as possible as an immediate substitute for the eye. Expressed in another way, the alternatives are (1) that the results of photo-electric measurements on some fundamental basis be referred to the visual system by suitable conversion factors, subsequent to the actual process of measurement, or (2) that the results of photo-electric measurements be made to conform to visual measurements of the same quantities by suitably choosing the conditions under which the cell operates (i.e., with suitable colour filter, etc.). The latter alternative is the practical one, widely adopted at the present moment, except, of course, in such fields as that of spectrophotometry; but it is probable that the former alternative has not received sufficient attention as yet, and may eventually provide a system for the measurement of radiation, luminous or otherwise, less arbitrary than the present visual system. With this latter possibility there is perhaps bound up the possibility of attaining a greater measure of uniformity in cells of a given type.

The present paper presents a survey, from the point of view of the standardising laboratory, of the difficulties, fundamental and technical, encountered by the authors in the practical application of the second of the above alternatives. The paper is divided into three main sections. Section I. deals with the basis of visual photometry, Section II. with the adaptation of the photo-cell to this basis, and Section III. with the type and magnitude of the errors involved in precision photo-electric photometry and with investigations resulting from their study.

NOTE.—This paper is restricted to photo-cells of the type in which anode and cathode are separated by an evacuated space.

I. THE BASIS OF VISUAL PHOTOMETRY.

1. The Source of Light.

The light sources of principal importance in photometry have hitherto been temperature radiators giving a continuous spectrum not far removed in type from the black-body spectrum. Such an energy distribution is of a particular type presenting little difficulty as regards colour matching in comparison with the difficulties encountered in the case of the gaseous discharge tube. The increasing use of the latter type of source is likely to raise the question whether a white light standard of luminous intensity is sufficiently fundamental for all purposes. It is possible that working sub-standards of the gaseous discharge type will be widely used for the photometry of sources giving line spectra.

It is to be noted that the present unit of intensity is based on standards of white light for several reasons, one of which is the fact that the unit is related to *visual* sensation. The justification for the adoption of standards of a particular spectral type is thus reduced in some respects by the use of the photo-cell, whose "seeing powers" are not confined

to the visible spectrum, and may vary widely, from cell to cell, even within the visible range.

2. The Receiver.

The main features to be noticed as affecting the use of the eye in photometric measurements are the following:—

(a) The absolute sensitivity, i.e., the ratio of sensation to stimulus is not susceptible of accurate measurement. The retinal stimulus depends on such factors as pupil diameter and point of entry of the rays so that the actual visual sensation produced by looking at a surface illuminated to a given degree is a function of a number of variables. The eye is, therefore, if only for these reasons, practically useless as an absolute measuring instrument and can only be used with any degree of accuracy for the assessment of *equality* of brightness or of contrast.

(b) The response of the eye, i.e., the ratio of sensation to brightness of the visual field, is of the logarithmic type, the sensation increasing in arithmetic progression as the illumination increases geometrically. In consequence the contrast threshold is proportional, over a considerable range, to the field illumination, and the actual amount of error (as distinct from percentage error) in the setting of a photometric balance decreases with the quantity being measured.

(c) The colour sensitivity of the eye is not, generally speaking, subject to great variations from one individual to another. The importance of the variations is, however, dependent upon the task which the eye is called upon to perform. In the case of the comparison of two black body (or similar) sources at different temperatures, the divergence between the results obtained by two different observers is generally not excessive (unless the temperature difference of the sources is large), and bears a systematic relation to the Y/B ratios (1) of the observers (2). If, however, the colour difference between the sources is excessive, or even if there is an apparent colour match (subjective), but the energy distributions of the sources are widely different, different observers may obtain widely different results, and it may not always be possible to find a *systematic* relation between an observer's Y/B ratio (as usually measured), and his divergence from the mean result, since the Y/B ratio may not be a sufficiently complete description of the observer's visibility curve. Such a situation might be met with in comparing the radiation from a discharge tube with that from a temperature radiator plus colour filter.

The main point to be noticed is that the reproducibility of visual measurements by different observers on temperature radiators of different colours at present assumes a general similarity in the colour response of the different eyes. The arrival of the discharge tube may introduce into visual work the same kind of complication which has existed from the outset in photometry with photo-electric cells. In the one case, the trouble is the abnormally wide colour difference between test source and standard lamp; in the other it is the difference in colour sensitivity between the photo-cell and the standard receiver, i.e., the eye.

(d) Talbot's Law has been verified for the eye to a high degree of precision over a wide range of illumination, and is generally assumed to be strictly obeyed. It should be noted here that we are not concerned with the actual illumination-sensation curve for the eye, that is, we do not say that introduction of a sector disc of ratio 0.5 cuts down the sensation by one-half, or, indeed, in any other definite ratio; we are simply concerned with the fact that the introduction of the sector disc of ratio 0.5 reduces the sensation to the *same* value as would be the case for a steady illumination of one-half the value of the interrupted one. This is so because the eye is a comparison, not a direct measuring instrument. In the case of the photo-cell, however, we may be concerned with the actual change in "sensation," since the photo-current, which corresponds to visual sensation, *can* be measured, and the illumination-current curve determined.

The foregoing summary of the basis of visual photometry has not taken account of the use of the eye as an absolute measuring instrument by the use of threshold values as units, nor have such effects as fatigue and the Purkyne effect been dealt with. Such matters, bound up as they are with physiological factors, are of lesser importance in a comparison with the photo-electric system. One disadvantage inherent in visual photometry may, however, be mentioned here. It is the practical complication following on the necessity for the juxtaposition of the illuminated surfaces whose brightnesses are being compared, and one the necessity for their being illuminated simultaneously. Neither of these limitations need be imposed on photo-electric work, and considerable advantage accrues in such operations as spectrophotometry.

II. ADAPTATION OF THE PHOTO-CELL TO THE VISUAL SYSTEM.

The characteristics of the photo-cell which demand comparison with the corresponding properties of the eye are the following:—

(a) The absolute sensitivity, or current per unit of radiation, can be measured accurately, and after calibration the cell can thus be used as a direct measuring instrument. No comparison lamp is necessary for photometric measurements if it be assumed that exposure to a given degree of illumination (of definite colour) will give a definite corresponding photo-current at any time during a given series of measurements. This assumption is valid if adequate precautions are taken to avoid the effects of fatigue (so-called) which may or may not be noticeable.

(b) If the further assumption is made that the cell output is proportional to the illumination, the colour of the radiation being constant, movement of the source and application of the inverse square law can be dispensed with. This assumption appears, however, to be an ideal difficult to realise precisely, although in the case of carefully-made cells the deviation from linearity of response is very small. This point is dealt with below.

The fact that the response of the photo-cell is linear, at least approximately, implies that where the actual error of observation of the photo-current is constant, the proportional error on the illumination or intensity measurement, expressed as a percentage, is inversely proportional to the quantity being measured. This implication has to be borne in mind in the design and operation of a photo-electric photometer.

The departure from linearity of the illumination response curve can be measured without the use of visual observations and solely by reference to precise mathematical relations (1). The cell can, therefore, be calibrated to an accuracy limited simply by the observational error in the photo-electric measurement together with certain other errors of a similar or smaller amount associated with the experimental methods. The total error associated with the deter-

(1) The Y/B (yellow/blue) ratio is the ratio of the transmissions, for light of a given colour temperature, of two standard coloured solutions, as measured by the given observer. The ratio thus depends on the colour characteristics of the particular eye to which it refers.

(2) H. Buckley, ILLUMINATING ENGINEER, April and May, 1934. W. S. Stiles, "Phil. Mag.," 7.812 (1929).

(1) N. R. Campbell, Trans., Opt., Soc., 32-33, 61 (1930); J. S. Preston, and L. H. McDermott, Proc., Phys., Soc., 46, 256 (1934).

mination of a point on the illumination characteristic is of the order of 0.1 per cent.

This apparent defect of the photo-cell does not, therefore, seriously detract from its usefulness from the precision aspect, although it would be fortunate if every photo-cell had automatically a precisely linear response so that the error associated with preliminary calibration might be eliminated from the total error on subsequent photometric measurements.

(c) The spectral sensitivity curve of a photo-cell depends on the material and structure of the light-sensitive layer, and is thus subject to very wide variations as between cells of different types. Further, the variation in the colour response as between different cells manufactured by the same process is considerable, individual characteristic curves being much more widely distributed about the mean than is the case for visibility curves of various eyes. For precise heterochromatic work, therefore, each photo-cell must be treated individually and combined with a particular colour filter to give an adequate approximation to the colour sensitivity of the standard eye (1). For less accurate photometry a given type of filter may be used for all cells of a given spectral type. But it is not yet possible to specify a standard cell-filter combination in the same way as the standard eye has been specified, i.e., as an agreed mean performance of a number of very similar units.

It is thus readily seen that the accuracy of photo-electric heterochromatic photometry (referred to the visual basis) depends on the adequacy of the colour correction attainable, and this involves two factors, namely, the limitation imposed by the impossibility (generally speaking) of finding a coloured medium having exactly the required absorption curve for use as the correction filter, and also the errors involved in the measurements necessary to determine the degree of correction attained. Considering the second factor first, the measurement may be made by one of two methods, either by spectrophotometric measurement comparing the cell output with the thermopile calibration of the spectrometer or monochromator, or by direct comparison of photo-electric and visual measurements on sources of different colours. The former method involves a very considerable amount of work for each coloured filter which may be tried out, and also necessitates a knowledge of the intensity response curve for the photo-cell, which may not be the same for light of different colours. The total error on such measurements would be considerable compared with the repetition accuracy of the cell itself. The latter method involves reference to visual standardisation, and this fact in itself imposes the visual limits of error on the system of photo-electric photometry. (The same criticism applies to the use of correction factors for measurements with an imperfectly corrected cell, for these have to be found by visual comparison in the first instance.)

Then there still remains to be added the systematic error due to the first factor named above, i.e., the difficulty of obtaining, with any filter of a reasonably high transmission, a sufficiently close approximation to the standard eye.

The foregoing considerations lead to the conclusion that for heterochromatic work the advantage of precision, on which the prestige of the photo-cell may be thought to be based, is almost, if not quite, lost in comparison with visual methods. The fields in which this advantage may be utilised to the full are the comparison of sources of the same colour, or operations such as the ageing of lamps where the colour change is slight. Further, the photo-cell should be of use in spectrophotometry, where sensibly monochromatic light is used.

(d) The application of Talbot's Law to photo-electric cells has been the subject of a number of investigations. Carruthers and Harrison (1) found that the law was obeyed for a number of cells having non-linear illumination response curves; that is, that a given reduction in illumination produced the same reduction in photo-current, to within 1 per cent., whether the illumination was reduced by a sector disc or by the appropriate movement of the light source. If, therefore, the photo-cell is employed as a direct measuring instrument in conjunction with sector discs, the same corrections should, if necessary, be applied for lack of linearity in response, as in the case of measurement of equivalent steady illumination. This suggests that the output of a cell with a non-linear characteristic can be divided into two parts—viz., a linear part varying as the illumination, and following its changes rapidly; and a non-linear part, which does not follow the rapid changes of a cyclically varied illumination, but which is related to its *mean* value (the frequency of intermission being sufficiently high) (2).

(1) J. S. Preston and L. H. McDermott, J.Sci. Inst., XI. 150 (1934).

III. SOURCES OF ERROR IN PHOTO-ELECTRIC PHOTOMETRY.

A. ERRORS CONNECTED WITH THE CELL ITSELF.

1. Illumination-Current Relation.—In practice the relation between illumination, of constant colour, and cell output at a constant (saturation) voltage, is generally not linear even for vacuum cells. Non-linearity of the cell should be distinguished from the effect noticed in a circuit containing battery, cell, and high resistance in series, where the volt drop on the high resistance changes with the photo-current, so that the voltage on the photo-cell changes also.

Fig. 1 gives experimental results for two typical cells, one a sodium vacuum cell,* the other a more modern thin-film potassium-on-copper vacuum cell. In the first case the cell voltage was 100, in the second

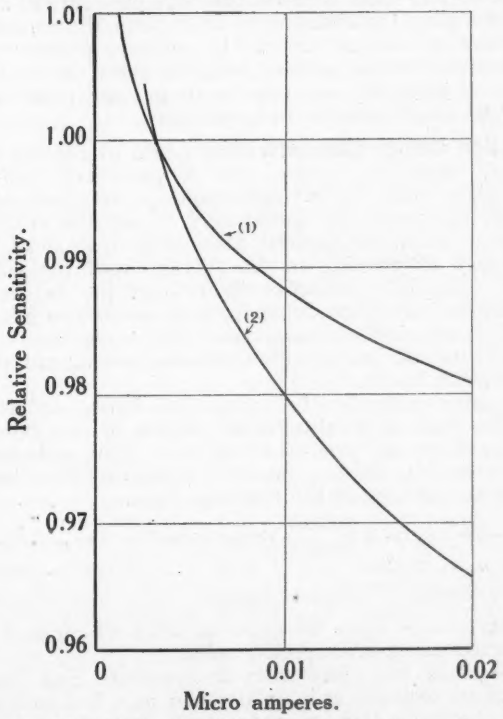

Figure 1. (1) Relative Sensitivity Curve for Potassium on Copper Cell (at 22 volts).
(2) Relative Sensitivity Curve for Sodium (Bulk) Vacuum Cell (at 100 volts).

(1) "Phil. Mag." VII., 1929, p. 792.
(2) See W. S. Stiles, "Phil. Mag." VII., 1929, p. 812. The illumination response relation developed in this paper appears to be of too simplified a form to apply to the use of a cell under steady illumination in most cases. The present authors put forward a simple theory, for which see Proc. Phys. Soc., 46, 256 (1934).
* Carruthers and Harrison loc. cit.

22. The abscissae are values of photo-current, while the ordinates give the ratio of current to illumination referred to some convenient arbitrary value as unity. It will be seen that over quite a moderate range of illumination, errors of the order of several per cent. are possible if due correction is not applied. While some cells of reputable make show considerably smaller deviations than those here given, it cannot be assumed without test that any particular cell has a linear response. The determination of the cell characteristic can be carried out either by utilising the inverse square relation to obtain the necessary range of illumination or by the summation of a number of light sources which can be lit singly or in groups at a definite voltage. As pointed out above, the result of a photometric comparison involving two unequal photo-currents cannot be assigned an accuracy greater than that attained in this "linearity" calibration, for which a reasonable mean figure is roughly 0.1 per cent.

It has been previously mentioned that there is evidence that the form of the illumination-current characteristic of a photo-cell varies with the colour of the light used to determine it. Moreover it appears that the differences between characteristics for the same cell for different colours may be of the same order as the divergence of these characteristics from the strictly linear relation. The non-linearity correction to be applied in any photometric measurement will then be dependent upon the colour of the light source and the type of cell compensating filter employed. Further, simple consideration will show that the operation of the photometer mentioned in III. 9 will be strictly valid only when the observing photo-cell is exposed to light of one colour throughout a set of measurements.

The non-linearity of a cell characteristic may involve particularly large errors in spectrophotometry if the cell is used, without previous calibration, as a direct measuring instrument, since large illumination ratios may be experienced. In ordinary photometry with uncalibrated modern cells the error due to this cause is generally not greater than 1 per cent., and may be much smaller in some cases.

2. Cell Colour Characteristic. Since in general the colour sensitivity curve for a photo-cell differs markedly from that of the average eye, it is necessary for heterochromatic photometry to use the cell in conjunction with a colour filter to give as near an approach as possible to the average visibility function. Complete correction is an ideal, the degree of realisation of which depends, first, on the simplicity of the photo-cell characteristic, and, second, on the possibility of finding colour media having suitable absorption bands.

We may quote here for comparison figures obtained for the ratio of the luminous outputs of two lamps, one gasfilled and the other vacuum. The necessary corrections for the non-linearity of the cell have been made in the case of the first two figures.

Photo-electric Ratio $\frac{\text{gasfilled}}{\text{vacuum}}$ without correction filter	= 1.340
" " " with " "	= 1.262
Ratio based on visual standardisation	= 1.261

These ratios show the order of error which may be expected using uncorrected cells.

They do not, however, demonstrate that good colour correction has been attained, as a first thought may suggest. It is easy to show that there is no limit to the number of different colour filters which may be used with a given cell to give the correct ratio between the candle-powers of a certain pair of sources of different colour temperatures. Moreover, the cell-filter combination used for the measurements just quoted was appreciably in error if a *carbon* lamp was compared with the gasfilled or with the vacuum lamp. A later change in filter composition, however, diminished this error without introducing appreciable alteration in the vacuum-gasfilled ratio.

Thus a colour filter may be selected to fulfil a limited number of conditions, such as to give correct ratios between the intensities of a certain number of sources of different specified colour temperatures. If the number of such imposed conditions is large and a cell-filter combination is found to satisfy them, there is a high degree of probability that the combination will behave under many other conditions very much as the eye does. Strictly accurate correction for all purposes is, however, only reached if the cell-filter combination has a spectral sensitivity exactly the same as that of the standard eye. Such an ideal cannot be reached in practice. It is, however, possible to select a combination which is not in error by more than 2 per cent. in the measurement of overall transmission for white light of coloured glasses of average density anywhere in the range from a selenium red to a cobalt blue glass. But for certain monochromatic radiations even this combination may be, say, 50 or 60 per cent. or more in error as compared with the standard eye.

Thus for the photometry of discharge tubes it will in general be a difficult matter to select a cell-filter combination of universal application. It will, however, be an easier matter to select a combination which will give correct results for the comparison of one given type of discharge tube with a specified black-body tungsten lamp standard. Alternatively, we may dispense with a colour filter altogether and use correction factors appropriate to any given pair of sources. This is equivalent to adopting the alternative (1) mentioned at the beginning of this paper.

Reverting, however, to the case of tungsten or grey body sources, colour correction of a cell is generally based on a comparison between a visual candle-power ratio and the result given by the cell-filter combination. The accuracy of the photo-electric photometer cannot then be made better, for heterochromatic work, than that of the visual ratio. Thus a limit of about 0.25 per cent. is set to the accuracy of the photo-electric photometer for heterochromatic photometry.

3. Changes in Cell Colour Characteristic. In certain cases, quite considerable changes may occur in the colour sensitivity of a photo-cell with lapse of time, these changes being due to corresponding changes in the structure of the light sensitive surface. The causes of such a change of structure after the cell is sealed are usually electrical or thermal. The passage of a large current through the cell, especially at high cell voltages, may cause some disintegration of the surface by ionic bombardment; or the raising of the temperature of the cell may cause distillation of a volatile alkali metal. The latter effect was noticed in the case of a cell investigated by the authors. It was found that, although the cell was described as a potassium on copper thin-film cell, its maximum sensitivity was at about 4,400 Å, as is the case for bulk potassium cathode, although the existence of the thin film on some parts at least of the cathode was indicated by the extension of the sensitivity toward the red end of the spectrum. At a previous determination, however, this particular cell had been found to be more *red* sensitive than the average eye, and the change is ascribed to the distillation of excess potassium, introduced into the bulb during manufacture, from the base of the cell on to the cathode. Such distillation will occur at a temperature only a little above the maximum shade temperature in summer.

Where it is impossible to avoid temperatures at which appreciable sublimation takes place, it is preferable to employ a cell of modern design containing no excess of alkali metal. Such a cell will not usually deteriorate through vaporisation of the thin film, since this does not take place at so low a temperature as evaporation from a free metal surface.

4. Temperature Effects in the Photo-Cell. Change in temperature of the cell may cause a temporary

reversible change in the output of the cell. Such a change in output may be due to a change in the dark current, a change in the true photo-current at constant illumination, or both simultaneously. Experiment shows that in general the true photo-current has a small negative temperature coefficient, while in some cases the dark current is much more seriously affected. Fig. 2 shows graphically the results obtained by heating a caesium-on-silver thin film cell. Observations of total current at constant illumination and of dark current were made at various temperatures, and the photo-current is plotted as the difference between these currents. It will be seen that the dark current rises rapidly with rise in temperature, the effect being reversible and due to thermionic

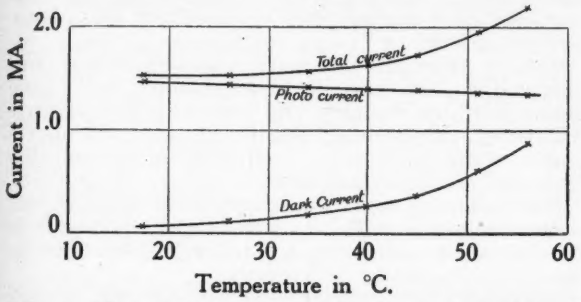

Figure 2. Effect of temperature change on current from photo-cell. Cell-Caesium on Silver thin film vacuum (temperature co-efficient of photo-current) 0.2% per °C.

emission from the caesium surface, which has a particularly low work function. The photo-current itself has a small negative temperature coefficient of about 0.2 per cent. per °C.

In a rubidium-on-silver thin film cell the dark current was virtually unaffected by temperature, but the photo-current again had a slight negative coefficient, average value about 0.2 per cent. per °C. The value of the coefficient in this case appeared to increase with rise in temperature.

In both the above cases the cell was exposed directly to the light from an electric incandescent filament lamp, no filter being interposed in the beam.

A test was carried out using a caesium thin film cell, illuminated through a separate glass window, to determine whether change of temperature of the window affected the photo-current. Some change in the photo-current might have been expected if the absorption of the window changed within the range of wavelengths over which the cell had appreciable sensitivity. The result of the test was negative, so that it may be inferred that change in temperature of the glass bulb of a photo-cell does not change its transmission in such a way as to affect the overall sensitivity of the cell.

B. ERRORS ASSOCIATED WITH THE AUXILIARY APPARATUS.

5. Temperature Co-efficient of Filter Transmission. The colour filter used to compensate a photo-cell for heterochromatic photometry is usually subject to variations in transmission with variations in temperature. A test was carried out on a rubidium-on-silver thin film cell with filter solution *M/2.6 cupric chloride, M/20 cobalt ammonium sulphate and M/270 potassium dichromate and the result is given in Fig. 3. Here the apparent intensity of the light source on an arbitrary scale is plotted against temperature of the filter. It is seen that the filter transmission has a negative temperature co-efficient of rather more than 0.3 per cent. per °C, so that a few degrees change in filter temperature may seriously vitiate exact photometric measurements. It is probable that gelatine filters behave similarly, though the value of the temperature co-efficient will,

* M = Molecular weight in grams (including water of crystallisation) per litre of solution.

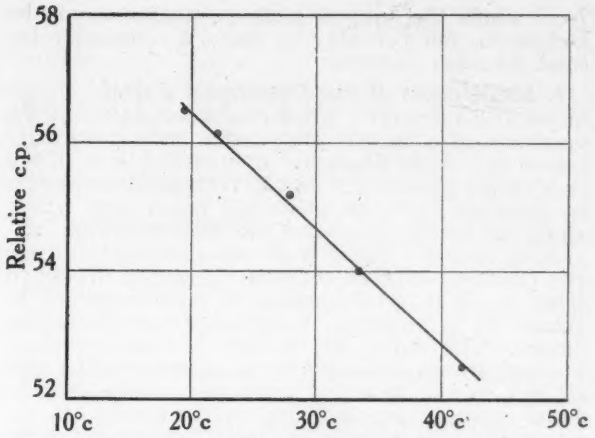

Figure 3. Change of observed c.p. of source with temperature of colour filter. (Average co efficient—0.33% per °C.)

of course, depend on such factors as whether an absorption band of the filter happens to correspond to the same wavelength as does a steep portion of the cell sensitivity curve.

6. Temperature Co-efficient of Electrical Resistances. In methods where a photo-electric current is measured by passing it through a high resistance and measuring the potential drop on the resistance, it is important that this resistance be of a stable character. Wireless grid leaks of the sputtered glass rod type were the first to be used at the National Physical Laboratory in a valve bridge circuit, but it was soon found that these were unsuitable owing to their high temperature co-efficient of resistance. Measurements showed that the particular leaks used had a temperature co-efficient of —0.4 per cent. per °C, suggesting that the sputtered film was composed of carbon. These leaks have now been replaced by a newer type in which the conducting film is deposited on a porcelain rod, and is said to consist of graphitic carbon.

7. Photo-Sensitivity of Thermionic Valves. Where the photo-cell and an associated thermionic valve are housed in the same casing in such a way that the thermionic valve is exposed to the light source it is essential to take the precaution of testing for photo-electric effect in the valve itself by doing a blank experiment with the photo-cell disconnected. This effect may be large enough in certain cases to interfere with accurate photometric measurement.

8. Distribution of Light Incident on Photo-Cell. It is common practice to use a highly diffusing window, say of opal glass, in front of the photo-electric cell, since the cathode surface is not equally sensitive over the whole of its area, and any slight changes in the distribution of the incident light would otherwise cause changes in the photo-current. This precaution is particularly necessary when directional observations are made on a light source, or sources, at different distances from the cell. On the other hand it involves loss of sensitivity which may be serious where a fairly dense colour filter is also interposed in the beam of light. If, therefore, a cell window giving a somewhat low degree of diffusion is used, it may be necessary to carry out a test to determine whether the diffusion is adequate. This may be done by comparing different types of lamp whose candle-powers are known, at various distances from the photo-electric cell. The lamps should preferably all be operated at the same colour temperature in order to avoid errors due to incomplete colour compensation of the photo-cell. Alternatively, if the photometer is of suitable design, the method described under the next section will show whether the diffusion is similar for all positions of the comparison lamp, other errors having been eliminated previously. It will generally be found that three ground glass surfaces equally spaced about 1 mm. apart, and with a limiting diaphragm in contact with the outermost surface,

from which the lamp distance is measured, will be sufficient. The cell may be about a centimetre behind the inner surface.

9. Straightness of the Photometer Bench. Errors of about 0.3 per cent. which were discovered in the operation of a certain photometer were eventually traced to a slight departure from straightness of the rails of the photometer bench. The photometer was so designed that the photo-cell could face either along the bench or toward the window of an integrating sphere. Equality of illumination for these two positions could be obtained by moving the bench lamp so as to give equality of photo-currents, as shown by a suitable electrometer and balancing circuit. The errors due to lack of straightness of the bench were measured by the summation of light sources in the spherical integrator. Six roughly equal sources were lit singly and in groups (in the integrator) at a definite voltage. The various corresponding distances of the comparison lamp on the bench for photometric balance were observed. Then, assuming the six nearly equal distances corresponding to the six individual lamps to be correct, the inverse square law was applied to calculate the distances which should have been obtained for groups of 2, 3, 4, 5 and 6 lamps together. It was then found that these distances did not agree with the actual observed distances. A particular case thus investigated was perhaps a little extreme, the range of error on the lamp distance due to change in tilt totalling about 3 mm.; but it must be emphasised that for measurement to an accuracy of ± 0.1 per cent. special precautions must be taken with such mechanical details as bench rails and carriages.

10. Stray Light. Since the repetition accuracy of a photo-electric photometer is certainly better than 0.1 per cent. when used at the maximum sensitivity, it is important that all precautions be taken to avoid stray light, the amount reflected from the velvet curtains of a photometer bench being of an appreciable order. Actual measurements show that on a bench of normal design, removal of the screening system increases the illumination at the photometer by about 0.2 per cent., with the lamp at 1½ metres distance.

11. Cosine Errors. Cosine errors, due to the dimensions of the source being too large compared with its distance from the photometer, become more important as the observational accuracy is improved. The errors are usually calculable, to a close approximation, and observations on the photo-electric photometer bear out the calculated figures.

CONCLUSION.

The foregoing review of the factors influencing the accuracy of photometric measurements made with photo-electric cells shows clearly that while theoretically the precision of photo-electric photometry may be pushed much higher than visual precision, the precautions necessary to make this precision available in practice are probably even more numerous than those associated with accurate visual measurements. This situation arises from two main causes—first, the difficulties peculiar to the adaptation of the photo-cell to the visual system, chiefly connected with the colour and illumination characteristics; and second, the fact that the higher the precision aimed at, the greater is the number of incidental factors influencing the final stated result, such, for instance, as straightness of bench rails, evenness in the illumination at the photometer head, and cosine effects. Note that these are uninfluenced by any improvement in the photo-cell.

Almost all the factors under this second group and some of those in the first can be investigated by means of the powerful method afforded by the summation of light sources, provided always that lamps of good repetition performance are available. The investigations are then independent of visual observations. In the case of certain factors in the first group, however, such as colour, the situation is not so favourable. It is true that here also the necessary observations can be made by the photo-cell itself, but the work involved would be very great and the final total errors probably large. For instance, to calibrate accurately a colour filter for compensation purposes, using a direct reading photo-electric spectrophotometer, one requires to know the illumination characteristic of the cell for each colour. In fact, the shape of the colour-sensitivity curve of the cell alone, as measured with a spectrometer, will depend slightly on the way in which the energy transmitted by the spectrometer varies with wavelength.

On account of such difficulties visually calibrated lamps are usually relied on for some at least of the necessary tests on a photo-cell intended for photometric work. The visual limitations as regards accuracy are then immediately imposed on the photo-electric system.

Finally, since the ultimate standard lamps employed for photo-electric measurements will have been calibrated visually, any errors in their calibration which, while inappreciable visually, are appreciable photo-electrically, will remain ineradicable from the photo-electric results.

Full reference to papers covering the scope of this review is hardly possible. The reader may refer to the following text-books for fuller information on many details and for references:

Campbell and Ritchie.—"Photo-Electric Cells" (Pitman, 1929). (New Edition in the Press.)

Zworykin and Wilson.—"Photo-Cells and Their Applications" (John Wiley, 1930).

Hughes and Dubridge.—"Photo-Electric Phenomena" (McGraw Hill, 1932).

Simon and Suhrmann.—"Lichtelektrische Zellen und ihre Anwendung" (Julius Springer, 1932).

Fleischer and Teichmann.—"Die Lichtelektrische Zelle und ihre Herstellung" (Theodor Steinkopf, 1932).

Institution of Gas Engineers Second International Gas Conference

The above Conference is to take place in Zurich during September 1-4. The last conference of the kind, held in London in 1931 (when the International Gas Union was inaugurated), was attended by delegates from twenty-three nations. From the programme, which contains a list of papers by British, Continental, and American experts, it is evident that the coming conference will be equally representative. The alternative itineraries prepared enable visitors to see some of the most beautiful scenery in the world, and the journey should be both instructive and agreeable.

Those interested should apply to Mr. J. R. W. Alexander, Secretary of the Institution of Gas Engineers (28, Grosvenor Gardens, London, S.W.1), for further particulars.

Obituary.

A. W. BLAKE.

We learn with great regret of the death of Mr. A. W. Blake, a valued member of the Association of Public Lighting Engineers, which occurred on July 20 after a short illness. Mr. Blake was Electrical Engineer and Manager in Willesden. In the course of the Conference in Margate last year a congratulatory telegram was dispatched to him on the occasion of Willesden becoming a Borough, and his consequently attaining the position of Borough Electrical Engineer .

Literature on Lighting

(Abstracts of Recent articles on Illumination and Photometry in the Technical Press)

(Continued from page 226, July, 1934)

I.—RADIATION AND GENERAL PHYSICS.

162. Reflecting Power of Powders. C. W. Bryant.

J. Opt. Soc. Amer., 24, *pp.* 139-142, *May*, 1934.

The reflecting power of quartz and marble in the crystalline form was determined for the spectral band of 80μ -150μ emitted by the Welsbach mantle. These materials were then powdered and the specular component of the radiation reflected from them was obtained as a function of the particle size and the pressure applied to them. The "Focal Isolation" method set-up for reflection was employed. F. J. C. B.

163. On the Variation from the Inside of a Circular Cylinder. Part III. H. Buckley.

Phil. Mag., Vol. 17, *No.* 113, *pp.* 576-581, *March*, 1934.

A theoretical paper in which the author discusses and derives an expression for the energy-radiation from the inside of a hollow circular cylinder closed at one end. L. J. C.

II.—PHOTOMETRY.

164. Sources of Error in Photometry. A. Langseth and E. Walles.

Nature, 133, *p.* 210, 1934.

Finite slit width causes an error in the determination not only of the maximum blackening of a spectral line, but also of the integral intensity, in photographic microphotometry. Values of the percentage error are given, calculated for a few cases. F. J. C. B.

165. A Photometric Diagram and the Application of an Elastic Scale. A. Sellerio.

Zeits f. Techn. Physik, 7, *p* 267, *July*, 1934.

A method is described for converting the ordinary polar curve diagram to a form in which areas are proportional to flux. The method is facilitated by means of a special variable scale. W. R. S.

166. Precise Light Measurement. A New Photocell Application. Donald G. Fink.

Electronics, 7, *pp.* 190-191, *June*, 1934.

A description is given of the lay-out of the photo-electric equipment for a photometer, which is stated to be exceptionally stable, and for which an accuracy of 1-10th per cent. is claimed. Two cells are used in series, one being illuminated by each source, and an electronic voltmeter is used to measure a small potential difference. S. S. B.

167. A Colour Correction Filter for Photo-Electric Photometry. J. S. Preston and L. H. McDermott.

J. Sci. Instr., 11, *p.* 150, *May*, 1934.

Details are given of the methods used to determine the appropriate colour of filter for three different cells. An aqueous solution cupric chloride, cobalt ammonium sulphate and potassium dichromate was selected as most generally useful. Curves are given to show the degree of correction produced. S. E.

168. A Rotating Flashometer. W. E. Forsythe and M. A. Easley.

Rev. Sci. Insts., 5, *pp.* 216-217, *June*, 1934.

The instrument described was constructed for the study of time characteristic and intensity variations of any light source of high intensity and short duration. Traces are obtained on a rotating drum of photographic paper. F. J. C. B.

169. Current Advances in Photographic Photometry. G. R. Harrison.

J. Opt. Soc. Amer., 24, *pp.* 59-72, 1934.

A critical discussion is given of the various methods of photographic photometry, in continuation of a previous paper (P.A., 73, 1930), bringing the subject up to date. F. J. C. B.

170. Yellow-blue Ratios and Personal Errors in Heterochromatic Photometry. W. S. Stiles.

Phil. Mag., Vol. 117, *No.* 113, *pp.* 660-668, *March*, 1934.

When a photometric match between brightness of different colours is made by a number of observers their results will differ owing to variations in the shape of their respective visibility curves. In this paper the author derives an approximate formula which gives the personal error of an observer in terms of his Y/B (yellow-blue) ratio, when two brightnesses of different known colour temperature are being matched. It is shown that errors computed with the formula are in satisfactory agreement with errors determined experimentally for observers possessing known Y/B ratios. L. J. C.

171. Condensed Tables for Colour Computation. T. Smith.

Proc. Phys. Soc., 46, *pp.* 372 *and* 478, *May*, 1934.

It is sometimes sufficient in the spectrophotometry of coloured materials to take measurements at intervals of 10 μ instead of the standard interval of 5μ. Tables are given for use in these cases, which give results indistinguishable from those derived from the standard observer tables. S. E.

III.—SOURCES OF LIGHT.

172. The Incandescent Lamp.

Lux, 5, *pp.* 69-82, *May-June*, 1934.

The article is divided into four sections. The economy of the electric incandescent lamp as compared with other illuminants is illustrated diagrammatically, its chief technical characteristics and the process of manufacture are described, and its applications are briefly summarised. In the final section the advantages of clear, frosted, and opal bulbs, and the uses of tubular daylight and other special lamps are discussed. J. S. D.

173. Characteristics of 40-watt, 100-watt, and 500-watt 115-volt Tungsten Lamps as a Function of Applied Voltage. W. E. Forsythe.

Gen. El. Rev., 37, *p.* 191, *April*, 1934.

A table is given showing the variation with applied voltage in the following variables in three types of filament lamp:—current, temperature, lumens per watt, watts, lumens and life. G. H. W.

174. The Characteristics of Some Lamps Intended for Special Purposes. W. E. Forsythe and E. M. Watson.

Gen. El. Rev., 37, *pp.* 251-2, *May*, 1934.

The nominal rating, efficiency and filament temperature is given for a number of special tungsten filament lamps commercially produced in the U.S.A. G. H. W.

175. A New Development in Carbon Arc Lighting. P. Mole.

J. Soc. Mot. Pict. Eng., 22, *pp.* 51-57, 1934.

Use is made of 8 m.m. copper-coated cored carbons. Two arcs are placed side by side and separate automatic feed controlled by the voltage drop in each arc. Flickering and blinking are reduced to a minimum. The lamps operate at 115 volts 40 amperes, direct current. F. J. C. B.

176. Direct-Current High Intensity Arcs with Non-Rotating Positive Carbons. D. B. Joy and A. C. Downes.
J. Soc. Mot. Pic. Eng., 22, pp. 42-50, 1934.

This arc differs from other high intensity arcs in that the positive carbon is copper coated so that it can be held some distance from the crater end, and it is non-rotating. The current, voltage, and general characteristics are given. The use of this arc is discussed, and it is suggested that it should take its place with the new A.C. High Intensity arc discussed in a previous paper in supplying the need from more light in the small theatre.

F. J. C. B.

177. A New White Flame Carbon for Photographic Light. F. T. Bowditch and A. C. Downes.
J. Soc. Mot. Pict. Eng., 22, pp. 58-61, 1934.

The characteristics of the National copper-coated M.P. Studio Carbon are described. Nearly 37 per cent. of the total radiant energy emitted is in the visible spectrum, and a greater emission of light is shown for the same current when compared with former carbons.

F. J. C. B.

IV.—LIGHTING EQUIPMENT.

178. Electric Signs.
British Standard Specification, No. 559—1934.

The specification is divided into three sections dealing respectively with Construction, Electrical Apparatus, and Wiring. A minimum thickness for letters of wood or metal and for glass panels is prescribed. Such points as supporting troughs, means of attachment, ventilation, and facilities for access are discussed. Requirements in regard to transformers, choking coils and resistors, lampholders, flashers, etc., are defined. The nature of cables and their finish, voltage tests and tests of moisture, absorption and flame tests are specified. Sections are devoted to the installation of cables for discharge tube signs and the wiring of filament lamp and box signs.

J. S. D.

179. Progress in Electric Signs. R. H. Hall.
Elect. 113, pp. 17-18, *July* 6, 1934.

A considerable increase has taken place recently in the colour range of cold cathode tubes available for sign lighting. Recent progress also includes the development of numerical sign indicators for both day and night use.

C. A. M.

180. A Special Study Lamp. H. B. Dates.
Light, 3. *No.* 4, pp. 12-13, *First Summer Issue*, 1934.

A description, with photographs, is given of a newly-designed table lamp. A 100 watt lamp is used in an inverted bowl of diffusing glass. Surface brightness limits have been considered.

C. A. M.

181. Miners' Safety Lamps. E. Lyon.
El. Review, CXV., No. 2,954, p. 7, *July* 6, 1934.

A discussion of the new Regulations of the Mines Department relating to miners' safety lamps, with remarks upon the different types available. Improvement has resulted in modern lamps by the use of higher voltages. The advantages of the nickel-iron alkaline cell are discussed.

J. M. W.

182. Portable Electric Lamps with Alkaline Accumulators for Domestic Uses. P. Basiaux.
R.G.E., 35, p. 867, *June* 23, 1934.

Discusses portable lamps in general and the points in favour of electric types. A description and a photograph is given of a new type of lamp with an alkaline accumulator.

W. R. S.

183. Aluminium for Reflectors. J. D. Edwards.
Am. Illum. Eng. Soc. Trans., 29, pp. 351-357, *May*, 1934.

Gives data on the reflection properties of aluminium for ultra-violet, visible, and infra-red radiation, and discusses the effects of surface treatments to reduce tarnishing. The new "Alzac" reflector (aluminium electrolytically brightened and oxidised) is described.

G. H. W.

184. Tests on "Alzac" Aluminium Reflectors. A. F. Dickerson.
Am. Illum. Eng. Soc., Trans., 29, pp. 358-363.

Tests were made on a series of specular and matt reflectors in "Alzac" aluminium. Overall light output and reflection factor results are given before and after depreciation tests.

G. H. W.

185. New Combination of Church Lighting Fittings with Loudspeakers.
Licht u. Lampe, 23, *No.* 13. p. 312. *June* 21, 1934.

Description of a lighting unit combined with a loud speaker, which has been installed in Regensburger Cathedral. There is a high wattage lamp inside the loudspeaker, while several lower powered lamps encircle the framework on its upper side. It is claimed that good light distribution is accompanied by good sound distribution.

E. S. B.-S.

V.—APPLICATIONS OF LIGHT.

186. Lighting: "A Century of Progress. W. D'Arcy Ryan.
Elect. Eng., 53, pp. 731-744, *May*, 1934.

The author gives a full description of the exterior lighting effects at the "Century of Progress" exhibition at Chicago, with illustrations of some of the equipment used and the results obtained.

S. S. B.

187. Lighting Calculations. "E. O. T."
Elect., 112, p. 851, *June* 22; p. 885, *June* 29, 1934; *Elect.* 113, p. 25, *July* 6; p. 76, *July* 13, 1934.

A series of four short articles is given dealing with the fundamental considerations used in lighting calculations.

C. A. M.

188. The Eye as Affected by Illumination. Le Grand H. Hardy.
Am. Illum. Eng. Soc., Trans., 29, pp. 364-384.

The author presents a comprehensive treatise of the effect of light or visible radiation upon the eye, including its physical, pathological, and physiological effects.

G. H. W.

189. Area and Brightness of Stimulus Related to the Pupillary Light Reflex. N. Luckiesh and F. K. Moss.
J. Opt. Soc. Amer., 24, *No.* 5, pp. 130-134, *May*, 1934.

Experiments were made to determine the relation between pupil size and fixational distance for a brightness-level of 0.1 milli-lambert and the variation in pupillary area with simultaneous changes in area and brightness of a circular test-field seen amid comparative dark surroundings.

The application of the results to lighting problems is discussed.

F. J. C. B.

190. The Smoothing of Light Flicker in Lamps Operated by Alternating Current. H. Anschütz.
E.T.Z., 55, pp. 10-12, *January* 14, 1934.

The author shows that it is possible to eliminate the effects of flicker in electric lamps operated by alternating current by mounting a number (n) of lamps in a common fitting and arranging that the currents in these lamps differ in phase by $\frac{\pi}{n}$ from one another. Experiments show that in the case of a fitting equipped with three lamps almost complete absence of flicker can be obtained by connecting an inductance in series with one lamp, a capacitance in series with the second and a resistance in series with the third.

L. J. C.

191. Incandescent and Discharge Tube Lighting. Anon.
Light, 3, *No.* 4, pp. 10-11, *First Summer Issue*, 1934.

A district office of a supply company in New Jersey is fitted with box-like ceiling fittings, each housing a 300-watt mercury vapour tube, and 600 watts of incandescent lamps. 50 foot candles are said to be obtained. A photograph is given.

C. A. M.

192. Gas Lamps which Harmonise with Surroundings.
Gas World, p. 695, *June* 9, 1934.

Photographs and a brief description are given of the way in which modern gas lighting has been made to harmonise with rural surroundings at Rickmansworth. The lamps, which consist of two-light No. 2 mantles, are of copper with an opal globe, fitted with clockwork control and mounted upon old tree trunks concreted into the ground.

J. G. C.

193. School Lighting. W. Sturrock.
Light, No. 4, pp. 24-26, *and* p. 30, *First Summer Issue*, 1934.

Descriptions are given, with photographs, of a number of new lighting installations in schoolrooms in America. In one installation the fittings used take a 450-watt mercury vapour tube and a 500-watt incandescent lamp, the latter acting as a ballast for the former.

C. A. M.

194. Manchester Central Library. Anon.
El. Times, 85, p. 820, *June* 21, 1934.

A brief account, with photographs, of the lighting at the Manchester Central Library. Among other features. the book rack lighting is said to be probably the best example of its kind in this country.

W. R. S.

195. Hotel Lighting. W. E. Carlson.
Light, 3, *No.* 4, *pp.* 28-29, *First Summer Issue*, 1934.
Details, with photographs and diagrams, are given of a colour lighting equipment of a dining-room at a San Francisco hotel. C. A. M.

196. Floodlighting of Hotel.
Gas World, *p.* 697, *June* 9, 1934; *Gas Journal*, *p.* 649, *June* 6, 1934.
A photograph and description is given of the floodlighting by gas of a hotel in Harwich, where a gas exhibition is being held. J. G. C.

197. West Ham Baths. Anon.
Elect., 112, *p.* 889, *June* 29, 1934.
A description is given, with photographs, of new lighting equipment at the West Ham Baths. Lay lights are fitted over a considerable portion of the ceiling of the largest bath, at the end of which there is a stage that includes a cyclorama in its equipment. C. A. M.

198. Floodlighting of Open-Air Bath.
Gas Journal, *p.* 808, *June* 13, 1934; *Gas World*, *p.* 698, *June* 9, 1934.
It is announced that the Southgate Borough Council have chosen gas as the means of lighting the open-air bath at Barrowell Green. The Tottenham and District Gas Company propose to use 6,000 candle power lamps for the main lighting and smaller lamps at the angles of the bath. J. G. C.

199. Lighting for Cranes.
Illumination Research, Tech. Paper, No. 15, *Part II., D.S.I.R.*, 1934.
This sequel to the previous technical paper on the subject which dealt with the lighting of docks, warehouses, and approaches, attempts to reconcile the points of view of the crane driver and the worker on the quay, i.e., the provision of adequate illumination of the load and the avoidance of glare from the lamps used. Three alternative methods of lighting are described, but no one of them seems completely satisfactory. J. S. D.

200. Clean Industrial Lights Are Effective Production Aids. J. W. Nash.
El. World, 103, *p.* 879, *June* 16, 1934.
A brief article referring to the problem of maintaining cleanliness of industrial lighting fittings in large installations. It describes a fitting which is suspended from a hook in position before being joined in the circuit, the electrical connector securing the fitting on the hook. Rapid removal for maintenance is obtained. S. S. B.

201. Gas Lighting in Sheffield.
Gas Journal, *p.* 96, *July* 11, 1934.
In his annual report, the City Lighting Engineer of Sheffield makes reference to the increased durability of mantles for modern gas lighting units. He reports that the old upright mantles had an average life of 270 hours. The life of the inverted mantle has considerably increased. In the year 1926-27, the average life was 1,153 hours, whereas in the year ended March, 1934, the average life was 1,795 hours. This is based upon the work of the 15,722 gas lamps in use in the city of Sheffield. The City Lighting Engineer makes some further observations regarding photometric tests on mantles, and reports a loss of only 7 per cent. from the initial light output measured on the horizontal plane, after 1,000 hours of use. J. G. C.

202. Emergency Light in Paper Mill Obtained from Floodlamps. A. P. Schnyder.
El. World, 103, *p.* 884, *June* 16, 1934.
A short note of an installation of floodlights, operated from storage batteries through a relay, as a source of light in a case of failure of the normal system of lighting in a paper mill. S. S. B.

203. Coal Washing. J. L. Tugman.
Light, 3, *No.* 4, *pp.* 6-8, *First Summer Issue*, 1934.
The lighting equipment of the inspection and washing sections of two coal mines in America is described with numerous illustrations. 500-watt lamps in reflectors, using blue cover glasses and giving 40-foot candles, are used for the detection of impurities. C. A. M.

204. Floodlighting at York.
Gas World, *p.* 732, *June* 23, 1934; *Gas Journal*, *p.* 902, *June* 27, 1934.
Photographs and description of the floodlighting of buildings by means of incandescent gas lamp projectors. The reports are interesting, in that they not only describe and illustrate the use of gas floodlighting units mounted on the ground, but also the use of smaller units mounted on floating craft, the gas in this case being supplied from cylinders in which it was stored at high pressure. J. G. C.

MISCELLANEOUS.

205. Psychological Values of Colour Lighting. H. Chevalier.
Jour. of Decorative Art, *pp.* 184-186, *June*, 1934.
A brief discussion of the influence of coloured light on processes of perception and its possibilities in the artistic sense. Charts illustrating the qualities of mixed paints and the effect of coloured light in altering the apparent appearance of coloured fabrics are presented. J. S. D.

206. An Atmospheric Dust Recorder. Willis G. Hayard.
Frank Inst. J., 217, *pp.* 571-590, *May*, 1934.
An apparatus is described for recording atmospheric dust, by impinging the dust on a slowly moving strip of film, and measuring the deposit by the absorption of a beam of light compared with that of a beam passing through clean film. The decrease in transmitted light is balanced by a motor-driven optical wedge in the unobstructed beam, the position of the wedge being recorded on a chart. The instrument is fully sensitive to rapid fluctuations in dust concentration, and can be used to measure very low values, far below smoke concentrations. It may also be made to operate auxiliary blowers, through relays, when the dustiness exceeds a specified level. S. S. B.

207. Determination of the Daylight and Sunlight available Within Buildings. H. E. Beckett.
Phot. J., 74, *pp.* 229-238, 1934.
Photographic, photometric, and various graphical methods of determining the daylight factor are reviewed and compared. The obtaining of flat projections of window openings photographically by means of a lens camera is restricted by the angular limitations imposed by the lens, and the author describes his use of a cylindrical pinsole camera, which will photograph almost the whole sky with one exposure. This camera can also be used for sunshine measurements. F. J. C. B.

Public Works, Roads & Transport Congress (1935) Awards for Papers

The Organising Committee of the above Congress have decided to offer the following prizes for papers submitted for discussion at the Congress to be held in November, 1935:—

1st Prize.—Gold Medal and 100 Guineas.
2nd Prize.—Silver Medal and 50 Guineas.
3rd Prize.—Bronze Medal and 20 Guineas.

An additional award of five guineas (excluding the above) will be given for each paper selected for discussion at the Congress.

We hope that some papers dealing with public lighting will be included in the list of those presented, and that one or more of them will merit an award. For the information of public lighting engineers and others interested we append a list of acceptable subjects, which, however, is not intended to be exhaustive:—

1. The Administration and Control of Public Lighting.
2. The Application of the British Standard Specification for Street Lighting and the Grading of Requirements in Main and Side Streets in Accordance Therewith.
3. Recent Advances in Public Lamps and Lighting Equipment.
4. Methods of Automatic Control of Street Lighting.
5. The Comparative Advantages of Central Suspension Lamps and Lighting from the Curb.
6. The Use of Lighting as an Element in the Control of Traffic (Illuminated Signs and Signals, Refuges, Direction Notices, etc.).
7. The Relation of Public Lighting to Safety on the Roads.
8. Public Lighting from the Standpoint of the Motorists and the Pedestrian.
9. Present and Future Lighting of Arterial Roads.
10. The Advantages of Street Lighting Load to Suppliers of Gas and Electricity.
11. Photometry in Relation to Public Lighting.
12. Characteristics of Road Surfaces in Relation to Visibility.

Papers entered for the Competition must be received before noon on Monday, December 31, 1934, by the Hon. Secretary of the Congress, Mr. S. M. Johnson, 84, Eccleston Square, Westminster, S.W.1, from whom fuller particulars of the conditions may be obtained.

Recent Patents

(Abstracts of recent Patents on Illumination & Photometry.)

No. 410796. "Improvements in or Relating to Luminous Electric Discharge Tubes."

Claude-General Neon Lights Limited, and Higgins, C., November 23, 1932.

When high voltage cold cathode positive column tubes are energised through cable enclosed in conductive sheathing undesirable flickering occurs, probably due to the capacity of the cable. According to this specification such flickering is eliminated by the connection of a choke or resistance closely adjacent to and in series with the tube or tubes. In a preferred arrangement an even number of tubes are connected in series and the choke or resistance is arranged symetrically with respect to the neutral point of a transformer secondary winding.

No. 410994. "Improvements in Luminous Electric Discharge Lamps."

The General Electric Company, Limited, August 14, 1932 (*Convention Germany.*)

This specification describes a positive column glow discharge lamp for providing an area of great surface brightness, the column being viewed along its length. The lamp comprises a single metallic enclosure divided into two compartments, each containing an electrode, by a metallic partition, the two compartments being in communication through a tube extending through the partition and also having apertures in the wall to permit the passage of light from the discharge. The enclosure may be a flat rectangular metal box, and may contain a metal, such as an alkali metal, which is vapourised by the discharge. A further electrode may be located outside the enclosure.

No. 411002. "Improvements in or Relating to Photo-Electric-Cells."

N. V. Philips' Gloeilampenfabrieken, December 31, 1931 (*Convention Germany.*)

In the manufacture of photo-electric cells utilising photo-sensitive electrodes comprising an absorbed film of alkali metal, the sensitivity often becomes lowered due to release of gas particularly from the glass of the cell. According to the patent a quantity of alkaline earth metal, such as barium calcium strontium is introduced into such a cell but does not form part of the photo sensitive electrode. Preferably the cell has two compartments, separated by a screen, one of which contains the photo sensitive electrode and the other the alkaline earth metal. The screen may be of material capable of taking up the excess of the alkali metal.

No. 411168, "Improvements in or Relating to Gas Lighting Means."

Webb, J., September 6, 1933.

This specification describes a form of electrical device for the remote control of gas burners, of the kind in which operation causes the gas to be turned on and also ignited. According to this qualification, such a device comprises a solenoid, which operates the gas valve, wound in opposite directions to induce like poles at opposite ends of its armature and a permanent magnet, which may be tubular and embrace the solenoid, with its poles near the ends of the armature. The apparatus may be arranged to close the gas valve by means of the multi-point switch.

No. 411127, "Improvements in Lighting Fittings."

Campbell, G., and The Benjamin Electric Ltd., November 29, 1932.

This specification describes an electric lighting fitting of the kind comprising a neck or carrier portion which houses the lamp-holder and a reflector or globe extending radially from the lower end of the neck, in which a supplementary reflector, detachable from the main reflector, reflects the light directly downwards, prevents hot air, etc., flowing into the neck portion, and also protects the user against contact with the live parts of the lamp-holder. The supplementary reflector may be integral with the lamp-holder, or it may be an annular disc or plate sprung into a groove in the main reflector.

No. 411218, "Improvements in or Relating to Electric Torches, Flash Lamps, and the like."

The Ever Ready Company (Great Britain) Ltd., and Terry, M. C., January 26, 1933.

This specification describes an electric battery lamp of the spot-light or focussing type, in which the switch is operated and the focussing effected both by rotation of the end cap of the body.

No. 411225, "Improvements in or Relating to Long Burning Oil Lamps, such as Railway Signal Lamps or the like."

Whillock, S. A., and The Lamp Manufacturing Company, Limited, February 8, 1933.

This specification describes a lamp of the type in which the air for combustion is pre-heated by the flame before passing to the burner by means of passages within the lamp casing having air inlets at the top and exits at the bottom. The top, the base at the burner, and the sides of the lamp case are formed with double walls, the outer and top wall being provided with a chimney cone, and the inner top wall with another concentric cone, the inner base wall having an aperture for the passage of the burner top, this aperture being surmounted by a cone having a flame passage.

No. 411656, "Improved Illuminated Bollard for Street Traffic."

MacFarlane, W., April 27, 1933.

This specification covers a street or like lamp comprising a lantern head having glazed openings in its under side and overhanging a supporting post having inclined outwardly and downwardly reflecting sides.

No. 411657, "Improvements in Connection with Miners' Safety Lamps and the like."

Hailwood, E. H., April 28, 1933.

This specification relates to a safety or like lamp equipped with a fitting in connection with the burner dome, whereby air can pass from the dome up the fitting, and be distributed towards the upper parts of the gauzes, thus tending to cool them.

No. 411714, "Improvements in and Relating to Electric Incandescent Lamps."

The British Thomson - Houston Company, Limited, August 20, 1932 (*Convention U.S.A.*)

This specification covers a string of electric lamps in which the conductors are joined permanently to the lamps by holders moulded to the lamp bases and conductors.

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"LUX"

(La Revue de l' Eclairage)

WE have pleasure in announcing to our readers that we have entered into an arrangement to receive subscriptions for the French Journal "Lux" (La Revue de l' Eclairage). The subscription per annum is 30 francs, the approximate equivalent of which in English money is Seven Shillings and Six Pence (7/6).

"Lux" is the only French journal which specialises in all aspects of lighting, it is the official organ of the Association Francaise des Ingenieurs de l' Eclairage (equivalent to the Illuminating Engineering Society in France).

It furnishes a complete record of interesting developments in lighting in France and on the Continent. It is fully illustrated and in particular devotes a considerable number of its pages to Decorative Lighting.

By studying these articles and the numerous photographic reproductions of modern lighting installations the reader can readily gain an excellent impression of French methods and practice in matters of Illumination.

Applications for subscriptions will be received by "The Illuminating Engineer," 32, Victoria Street, London, S.W.1.

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LONDON SALES OFFICE & STORES: 23, Bartlett's Buildings, Holborn Circus, E.C.4. 'Grams: "Cryselco Lamps, London." 'Phone: Central 9841 (2 lines); and at Thanet House, 231-2, Strand, W.C.2. 'Grams: "Cryselco, Estrand, London." 'Phone: Central 1742 (3 lines).
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Telegrams: "Cryselco, Kempston, Bedford." Telephones: Bedford 3277 & 3278.

Pleasure Giving Lighting for Public Gardens

The growth of cities, the ribbon development of their approaches, and the improved surroundings of modern suburban dwellings have increased, to the town dweller, the value of the parks and public gardens. Yet, owing to the necessity of earning his daily bread, his opportunities of enjoying these beautiful and healthful spots is limited, so far as daylight is concerned, to holiday times.

The illumination of these valuable amenities should, therefore, be regarded as a matter of public interest, and the night view we are able to give of a walk in the Thiergarten, the public park almost in the centre of Berlin, gives a good impression of what has been accomplished in this respect.

The rows of columns supporting semi-translucent cups surmounted by inverted multifaced conical structures capped by circular reflectors, of calculated curvature, give, as shown, a glare-free, almost shadowless, illumination emitted from a height that gives comfortable light on the tables seen on the right-hand side. The perspective view of the extremity of the path, and the absence of reflections from the overhead foliage, are notable features of this installation, as seen after dark. The colouring of the standards and their luminaries is also pleasing, and their appearance by daylight is unobtrusive.

An initial installation of pleasure-giving illumination, on appropriate lines, might well be added to the Charing Cross Embankment Gardens, in London, which are so deservedly popular by day—thus furnishing an example by which other municipalities might profit, and a demonstration to country and foreign visitors, how pleasure-giving illumination can add to the joys of life.

A view of the original Lighting Fittings used in the Thiergarten, Berlin.

Training Doctors in the Use of Light

The equipment of a lighting demonstration room at the London School of Hygiene and Tropical Medicine, where a course in lighting practice is now definitely included in the curriculum, is yet another example of the way in which the necessity for increased knowledge of lighting is growing in importance from day to day. The room contains several methods of lighting which can be operated separately, and is used for showing post-graduate students and fully-qualified doctors the advantages resultant from good lighting, and the bearing which light has on economics and health. Many of the men who study here will hold responsible positions affecting large numbers of the community. To such men, who will become Medical Officers of Health, Medical Officers in factories, and managers of large industrial and engineering concerns, information of the latest developments in modern lighting practice is of the utmost importance.

The London School of Hygiene and Tropical Medicine is to be commended on the step it has taken to provide doctors and students with information concerning a subject which is of growing and ever-present importance.

Illuminated Numbers for Houses

According to the "Daily Telegraph," "Doors of Berlin houses are to be fitted with illuminated number indicators at a cost of £125,000, under the Göring plan to help unemployment in the electrical industry."

If a similar scheme were adopted in Great Britain, it would assist in decreasing unemployment, and would lessen the difficulties of strangers in unfamiliar neighbourhoods.

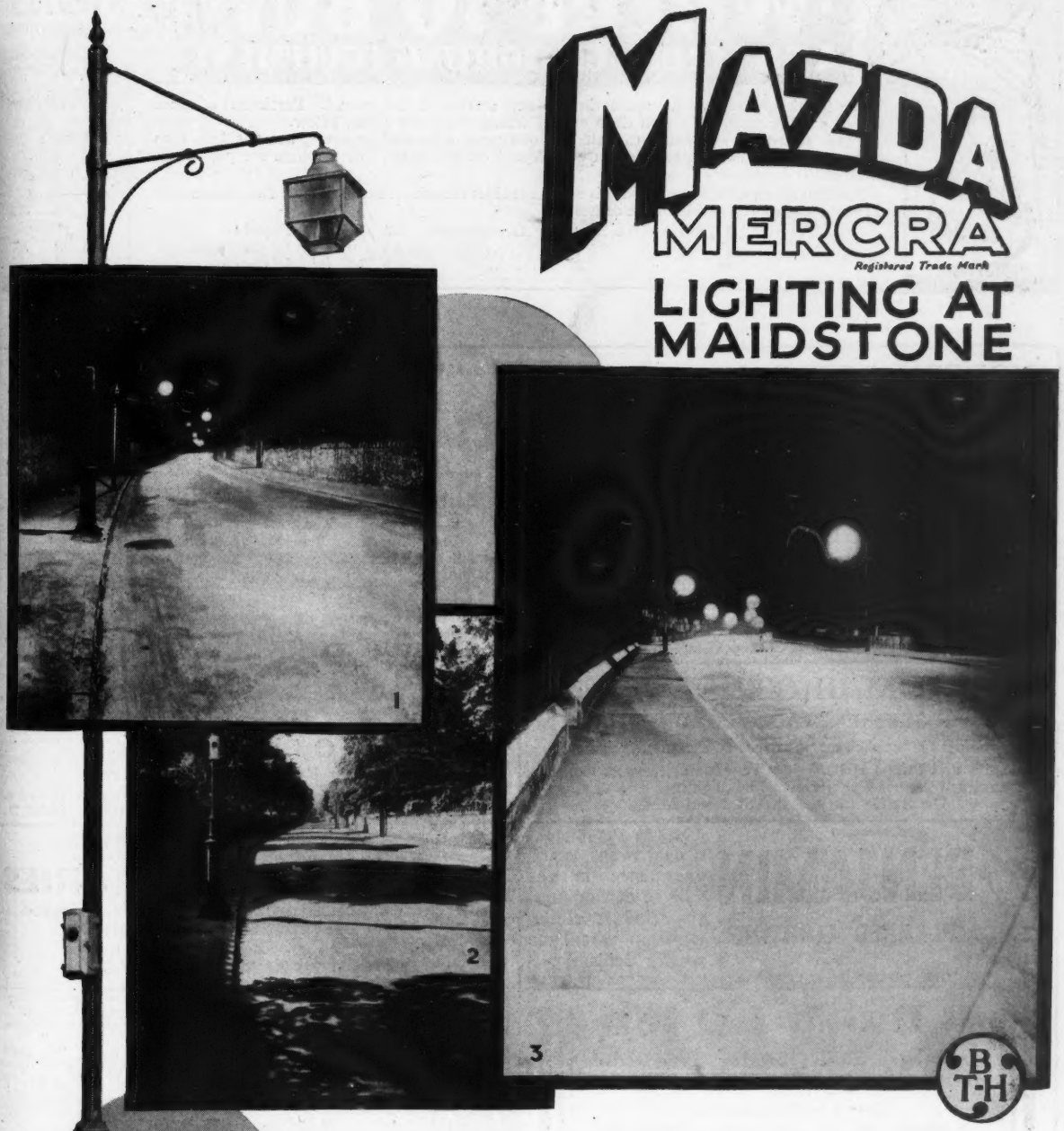
Every day money and tempers are lost in trying to find strange houses after dark. We all know, as visitors, what it feels like to travel up and down a street looking for a house while the taximeter is ticking up threepences; and, as householders, we know what it is to be expecting a guest long overdue and to hear the inevitable excuse that the house could not be found.

Of the 11,200,000 odd houses in Great Britain few indeed are yet equipped with illuminated numbers. Here, therefore, is a field ready and waiting for development. New building estates could include such lighting without incurring any extra expenses, as a small lamp can easily be made to serve the dual purpose of lighting the entrance and the house name or number.

MAZDA MERCRA

Registered Trade Mark

LIGHTING AT MAIDSTONE



MAZDA MERCRA LAMPS AND B.T.H. LANTERNS ARE MADE IN RUGBY, ENGLAND

M3515

The lighting of London Road, Maidstone, has been vastly improved by the installation of Mazda Mercra Lamps in B.T.H. Diron Lanterns. Units are mounted 25 feet high and spaced 170 feet to 200 feet apart. Photographs 1 and 2 are night and day views of a narrow portion of the road, while photograph 3 shows a wider section. The lamp standard with control box and Diron Lantern are shown at the left of the page. *Submit your street-lighting problems to B.T.H Engineers*

THE BRITISH THOMSON-HOUSTON CO. LTD., CROWN HOUSE, ALDWYCH, LONDON, W.C.2.

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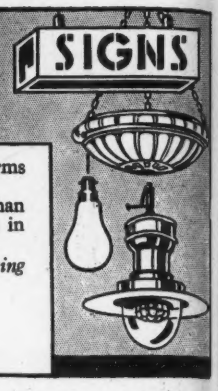
A DIRECTORY OF LIGHTING EQUIPMENT



We invite applications for spaces in this new section of the journal. Particulars of terms for each space (approx. 1 inch deep and 3⅛ inches wide) are given below.

These terms are equivalent to **half our ordinary advertising rates,** but not less than 12 successive monthly insertions can be accepted on this basis, and amounts are payable in advance.

Payment for an advertisement in this section entitles the advertiser to receive *The Illuminating Engineer* during the period of the contract.

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employing light sensitive Photo-cells.
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TRADE NOTES AND NEWS

Elm Works, Ltd.

We recently had the pleasure of visiting Elm Works, Ltd., at Summerstown, which for several reasons are of considerable interest to lighting engineers.

The manufacture of lighting equipment has been carried out in these works for many years. In its present form the firm of Elm Works, Ltd., dates from 1903, but even before then the same class of work was carried on.

The firm is truly concerned with "illuminating engineering" in the sense that it handles *all* forms of lighting equipment, both gas and electric. We have before us copies of their lists relating to both forms of lighting. Typical modern suspension units, employing multiple mantles, are shown in variety. Such special devices as the "Stripolite" equipment, with a row of mantles backed by a vertical reflector, are also included, and we were interested to see at the works a gas floodlighting unit of recent design. Electric street and industrial lighting fittings are likewise well represented in current lists, many familiar forms being shown.

At the time of our visit much work on units of this kind was in progress. Besides the wide range of lighting equipment illustrated in their own catalogues, we are betraying no secret when we state that Elm Works, Ltd., also manufacture many varieties of units which are put out by other firms associated with gas and electric lighting. In addition, they are particularly well equipped to deal with conversion and repair work, and their services are already in demand by local authorities for work of this kind. There may, however, still be many public lighting engineers who would be glad to know of the existence of a firm prepared to handle jobs of this kind. Reflectors of special contour can be spun on the premises, and a feature is the production of "one-piece" casing for lamps, which lasts very much longer than those having joints, within which rain can penetrate.

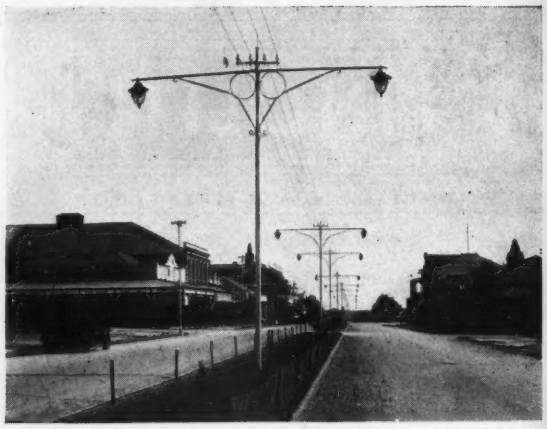
The works is equipped with an enamelling plant, which, besides being applied to reflectors and other lighting material, is proving of great value for the finishing of heating appliances, just now in great demand.

The Manufacture of Ice Cream

This is the title of an excellently illustrated and informative booklet (No. 240 of "A Thousand and One Uses for Gas") issued by the British Commercial Gas Association—very opportunely during the recent hot weather. It may be news to some that an ordinary gas boiling ring serves as the energising force of a popular freezing apparatus—that gas may serve indirectly as a source of cold as well as directly as a source of heat!

Another illustrated booklet for which the B.C.G.A. is responsible is entitled "How to Heat your Greenhouse." In this case, also, the information is practical and well presented. Recalling Mr. Eck's recent lecture, we should like to see issued, as a companion booklet, "How to Illuminate Your Garden at Night."

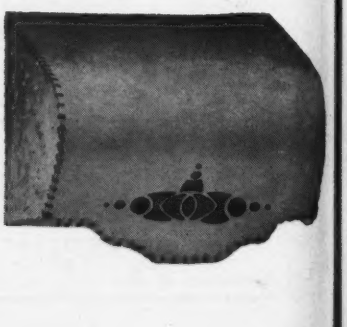
Street Lighting in S. Africa



The above illustration shows an installation of special G.E.C. street lighting units recently installed at Krugersdorp, South Africa. The lanterns are of special design and fitted with rippled outer globes and Wembley light-distribution refractors. In addition to the installation of these units in the main street of Krugersdorp, the British General Electric Co., Ltd., of Johannesburg, has secured the order for the whole of the street lighting fittings (comprising 800 Wembley asymmetric type units) for the secondary streets.

BED LIGHT SHADES

A list recently issued by Siemens Electric Lamps and Supplies, Ltd., contains a most representative series of designs of shades for pendants, table standards, and bed lights, executed in Rhodialine and parchment. We reproduce two pleasing forms of bed light shades, suitable for attachment at the head of the bed in the approved modern manner. The soft and decorative effect of these materials still exerts its charm. Even in this age of efficiency, their popularity as a lighting medium remains undiminished.



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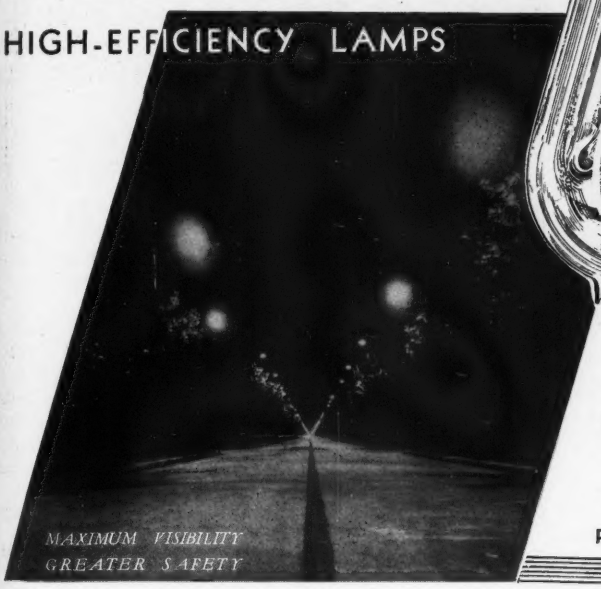
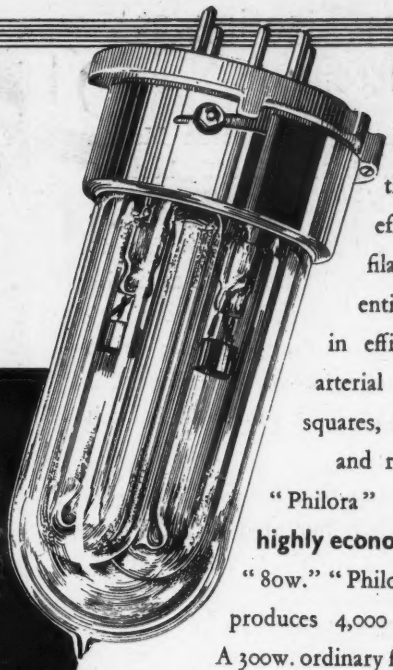
. . . . . the pioneer of modern

HIGH-EFFICIENCY LAMPS





The "Philora" sodium lamp, the new lighting unit with three to four times greater luminous efficiency than ordinary filament lamps, creates entirely new possibilities in efficient lighting of arterial roads, public squares, factory grounds and railway yards. "Philora" lighting is **highly economical.** An "80w." "Philora" lamp produces 4,000 lumens. A 300w. ordinary filament lamp would have to be used to obtain the same results. "Philora" lighting is **safer,** it gives greater visibility and does not dazzle.

Photos of existing installations, together with full information, will be forwarded on request.

PHILIPS LAMPS LTD. 145 Charing Cross Rd. W.C.2.

Trawling by Floodlight

Herring-fishing by searchlight is one of the latest developments of the fishing industry, the powerful beams of 1,000-watt lamps being used to lure the fish into the nets.

The novel feature of this method of fishing is that the drifters or trawlers on arrival at the banks sweep the water with searchlights, the Norwegian fleets which have adopted this procedure using ordinary Philips floodlights such as those used in the floodlighting of buildings. On reaching the scene of operations soundings are taken with an echo plummet, in order to locate the herring-shoals. But for the herrings to be caught in numbers, they must be drawn to within 30 fathoms of the surface.

While the attraction of light for animals and birds is well known, and has often been made use of by hunters, it has never before been used in deep-sea fishing, probably owing to the difficulty of finding a form of light at the same time sufficiently brilliant and durable.

It has also been found that the herring-shoals always follow the trawlers carrying the most powerful lights.

ARE YOU GOING TO ABERDEEN?

Entries for the Eleventh Annual Meeting and Conference of the Association of Public Lighting Engineers, to be held in Aberdeen during September 17-20, are now being received and tickets for the various events allotted.

Have you yet sent in to the Hon. Secretary your form specifying the tickets required?

Have you sent in to the Hon. Editor (Mr. E. J. Stewart, 20, Trongate, Glasgow), the information he needs on the progress in public lighting in your locality?

Have you (if an exhibitor) yet sent in to the Hon. Secretary particulars of your exhibit for inclusion in the catalogue?

SITUATION VACANT

LEADING CONCERN REQUIRES first-class ILLUMINATING ENGINEER with thorough commercial experience for responsible position. Write Box No. 159, "Illuminating Engineer," 32, Victoria St., London, S.W.1.

ERRATA.

Our attention has been drawn to an oversight in the programme of the A.P.L.E. Annual Conference which appeared in our last issue (p. 224). The author of the paper on "Road Surfaces and their Influence on Public Lighting" is Mr. J. M. Waldram, who is associated with the Research Laboratory of the General Electric Co., Ltd., at Wembley (the initials of his father (Mr. P. J. Waldram) were inadvertently given.)

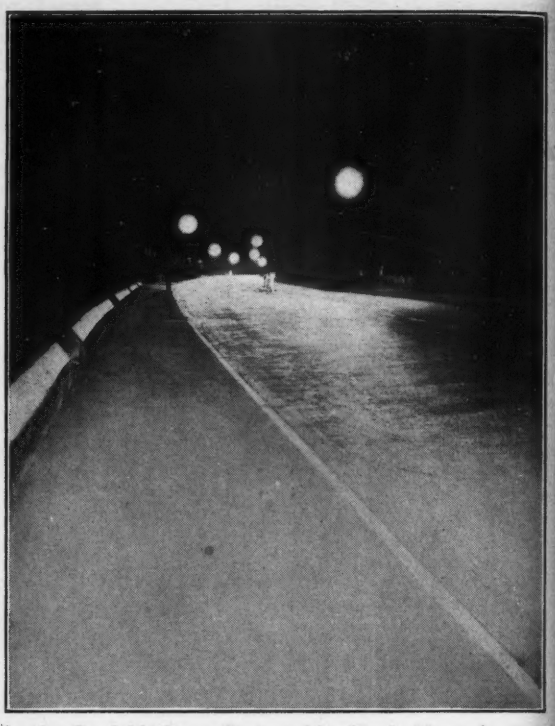
Mazda Mercra Lighting at Maidstone

Electric discharge lighting with Mazda Mercra lamps in B.T.H. Diron lanterns has recently been installed in London Road, Maidstone.

The road varies in width from about 48 feet to about 20 feet, and this narrow bottle-neck has in the past been a source of great danger to the considerable traffic which has to pass through it. No doubt the improved lighting now installed will render driving at night along this section of the road much less dangerous.

Each lighting unit consists of a B.T.H. Diron lantern and Mazda Mercra lamp, mounted on posts at a height of 25 feet, and spaced 170 feet to 200 feet apart. The posts are placed on alternate sides of the road, excepting at certain bends.

The illumination on the road surface varies between 0.1 foot-candles on the wide section, to 0.2 foot-candles on the narrowest and most dangerous portion.



London Road, Maidstone, illuminated by Mazda Mercra lamps in B.T.H. Diron Reflectors.

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Metropolitan Water Board.—For twelve months' supplies of Osram metal filament gas-filled and vacuum lamps.

SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD.

Ayr County Council.—For the supply of Siemens electric lamps for twelve months commencing September 1, 1934.

A Novel Form of Hand-lamp

The attached illustrations show a novel form of hand-lamp marketed by the "Typerlite" Company.

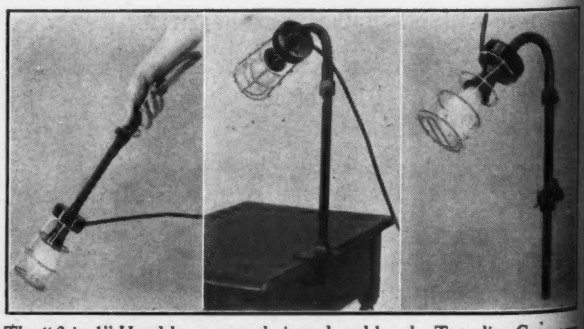
The hand-lamp, which is made in accordance with Home Office requirements, is supplied complete with 9-ft. C.T.S. cable, and is mounted on a reinforced metal flexible stem, which enables the hand-lamp to be bent to any desired angle.

By means of the thumbscrew, the wood handle can be instantly detached, thereby enabling the head of the lamp to be used as a wall bracket or a clamp-on fitment, as illustrated; the wall bracket, and clamp, and the square steel stem are the usual well-known "Typerlite" components.

This lamp, which is to be known as the "3-in-1 hand-lamp," is specially suitable for use in private garages, outhouses, and similar places where a temporary light is required.

The Mersey Tunnel

A notable event on July 18 was the opening of the Mersey Tunnel, which, it may be recalled, was visited by members of the Illuminating Engineering Society in connection with the special meeting in Liverpool on December 6, 1933. The interesting method of lighting the inside of the tunnel by means of incandescent lamps mounted behind panels of diffusing glass recessed in the walls was then described. For the illumination of the entrances Osira lamps in large bowl fittings mounted on pylons 60 ft. high., supplemented by lanterns on 30-ft. columns containing 1,500-w. Osram lamps, have been adopted. One is very glad to observe that in this tunnel lighting conditions in keeping with its importance have been adopted. The methods certainly constitute a great improvement on those of the past.



The "3-in-1" Hand-lamp recently introduced by the Typerlite Company.

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NIGHT PHOTO OF WEST HAM BATHS SHOWING THE UNIFORMITY OF THE LIGHTING BY SPECIAL HOLOPHANE LAYLIGHT REFLECTORS

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